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Macromodels:

The farm sector doesn't fit

see page 1

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In This Issue

"I do philosophy like a person who is always missing something and having to look for it again: now my glasses, now my keys." These words were enclosed in parentheses in the midst of notes on the subject of certain knowledge that Ludwig Wittgenstein drafted during the last year and a half of his life. Are we to consider this as an aside by a man who recognized that, after years of penetrating reflection, his mind was beginning to deteriorate? Or was he, in his mature and considered wisdom, offering us an important insight into the limits of knowledge? I think the latter.

We appear to do economics like a person who is always missing something and having to look for it again. Now a variable is taken as exogenous when it should be endogenous, and now a critical variable is omitted from the analysis altogether. It is traditional in economics to believe that we can isolate and examine all the variables relevant to a problem. But there is also a tradition which recognizes that in the real world everything is somehow interconnected with everything else and that the method of analysis requires simplification and abstraction. Perhaps it is in the nature of epistemology that we must always do economics as if we are missing something and having to look for it again.

The articles in this issue focus on things that are missing. The first article, reviewing a number of macroeconomic models used in the United States and elsewhere, finds that a satisfactory, endogenous agricultural sector is missing from many macroeconomic models. Reasons are given why an intellectually sound, endogenous agricultural sector would make these models more useful in achieving their stated purposes, and evidence is presented that these models tend either to ignore agriculture or to treat it as exogenous. One anonymous reviewer of the article, who works in the National Economics Division of ERS, observed that he knew from experience that the domestic U.S. models suffered from the missing component, but he had always supposed the models used abroad included it. And a reviewer who works in the International Economics Division, and who knew the weakness of the agricultural sectors used abroad, was surprised to learn that the domestic U.S. models were missing the same element.

The second article focuses on spatial aspects of rural development and finds that the functional relationship between geographic space and economic growth is missing from many rural development models. The author reviews a sample of the small body of literature that concentrates on this missing ingredient. The literature that ignores space and considers other factors affecting growth is reviewed by the same author in volume 3 of *A Survey of Agricultural Economics Literature: Economics of Welfare, Rural Development, and Natural Resources in Agriculture,* edited by Lee R. Martin. The article presented here is based on one segment of that review.

Clark Edwards

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The Agricultural Component in Macroeconomic Models

By William E. Kost*

Abstract

Many of the operational macroeconomic models examined either ignore or treat the agricultural sector as exogenous. When the sector is treated as endogenous, it is most likely structurally misspecified and/or too small to provide much information about agriculture. Given the increased awareness about economic interdependence among sectors, the importance of agriculture, the growing demand for more detailed forecasts, and the growing elaboration of econometric models, both agricultural economists and macroeconomists should direct more attention to making agricultural sectors of macroeconomic models endogenous.

Keywords

Macroeconomic models, Agricultural sector models, Model linkage

The last decade has witnessed a proliferation of econometric models, especially macroeconomic models. Macroeconomic modeling efforts have been increasingly used to forecast future economic behavior and to analyze the impacts of alternative economic policies. This trend has been accompanied by a growing awareness of the interrelationships between the various sectors of an economy and between different national economies. This situation is particularly true for agriculture.

With high rates of inflation and reduced real income growth, food becomes a more important part of the consumer budget. As agriculture becomes more industrialized and, therefore, depends more on nonagricultural inputs, the demand for the products of many industries depends increasingly on the economic well-being of the agricultural sector. With rising raw materials and energy prices and the reduced economic independence of both the agricultural sector and the national economies, agricultural markets depend increasingly on policies in the rest of the economy. As world population grows, food demand grows. For countries with large or growing populations, domestic food demand becomes increasingly important. Thus, for exporters or importers of agricultural products, agriculture becomes increasingly important.

In this article, I evaluate the impact these changes have had on macroeconomic modeling. Only recently have enough preconditions existed to make such a study relevant. First, agriculture must be important (or be perceived as important) before agricultural details should be incorporated into macroeconomic models. Second, macroeconomic models should provide (or potentially provide) some benefits to decisionmakers prior to any consideration of expanding or modifying them to provide agricultural detail. Finally, enough macroeconomic models in current use should be documented in sufficient detail to show just how agriculture is currently treated. Only then can we evaluate the appropriateness of the model specification to capture the agriculture/nonagriculture interaction or can we make recommendations on how models can be modified to capture this interaction better. A survey of the specifications of the agricultural block of several macroeconomic models allows me to evaluate the appropriateness of these specifications and to make recommendations on the direction of future research.[1]

The Importance of Agriculture to the National Economy

The concern about agriculture/nonagriculture interrelationships results largely from an increased awareness of the feedbacks inherent in economic systems. Macroeconomic models provide endogenous values for those variables—such as disposable income—that drive separate agricultural sector models. These variables are determinants both of consumer demand for food and of factor supply of agricultural inputs. Enclosing the agricultural sector in a macroeconomic model allows us to conduct an endogenous examination of these feedbacks. Macroeconomic models are also based on national account concepts and identities that are aggregations across sector components. Thus, agriculture is crucial to the complete specification of any macroeconomic model. Any significant change in one component changes the sum, and changes in the agricultural sector are frequently significant enough to affect national aggregates. There are several other reasons why sectoral detail should be included in macroeconomic models. Many macroeconomic model clients (policymakers, businessmen, social scientists, and others) are interested in the performance of specific sectors of the economy—including the agricultural sector—as well as in the performance of the total economy. This interest is partially generated because policy stimulus responses differ among sectors. Furthermore, many public policy proposals are themselves sector specific. These sector policy proposals can be explicitly simulated only if the model has explicit sector specifications.

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*The author is an agricultural economist with the International Economics Division, ERS. He wishes to thank Clark Edwards, Vernon Roningen, and an anonymous reviewer for their helpful comments.

[1] A study of the modeling interrelationship between agriculture and the rest of the economy can be evaluated from two perspectives. How has agriculture been incorporated into macroeconomic modeling? How have nonagricultural factors been incorporated into agricultural models? The Subotnik paper (*19*) takes this latter approach. Italicized numbers in parentheses refer to items in the references at the end of this article.

These above arguments imply that at least a few individual sectors should be explicitly included in macroeconomic models. One would hope that forecast accuracy will improve if sector detail is included, although it need not. The principle argument for including sector detail hinges on an interest in sector performance. If detail is to be included, and if one views macroeconomics from an aggregation perspective, then appropriate feedback mechanisms must be included; each type of variable should both affect and be affected by the other type of variable.

The relevant question then becomes: How important are the various sectors to the total economy? If a sector is not important, there will be little feedback from that sector to the macroeconomy. However, if that sector is important, there will be significant feedback and the details of that sector should be modeled. Therefore, the initial issue is the importance of agriculture to the total economy.

I have already alluded to the growing importance of primary products, particularly agriculture. I will now attempt to quantify the relative importance of agriculture to the total economy in countries for which operating macroeconomic models already exist.

Many criteria can be used to measure agriculture's importance to the total economy. In many countries it accounts for a significant portion either of total production or of total consumption. If agriculture is not important from these viewpoints, it may still be an important component of a country's international trade. If so, it should be explicitly included in a macroeconomic model. The way agriculture's importance to a country is defined indicates just how the agricultural sector should be specified.

Table 1 shows the relative importance of agriculture to the total economy of 13 countries: Australia, Austria, Belgium, Canada, Finland, France, Italy, Japan, the Netherlands, Sweden, the United Kingdom, the United States, and West Germany. The data show the relative importance of agricultural production, consumption, imports, and exports to total production, consumption, imports, and exports for the 1960-75 period. These 13 countries represent the Project LINK countries documented in (*20*). The time period covers most of the sample period over which the LINK models were estimated. As most operating macroeconomic models deal with developed countries, these Project LINK countries represent a reasonable sample.

Table 1—Relative importance of agriculture to the economy, by country, 1960-75

Country	CONS		PROD		IMPORTS		EXPORTS	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
	Percent							
Australia	29.7	3.0	8.9	2.2	9.0	3.9	64.1	13.3
Austria	38.1	3.6	7.9	2.0	16.0	5.6	9.9	6.3
Belgium	31.7	2.3	4.7	1.2	17.3	3.1	10.0	.6
Canada	23.4	1.3	4.7	.8	12.8	4.7	22.5	12.5
Finland	40.2	2.1	14.0	2.5	14.4	5.3	5.6	.6
France	33.1	6.4	7.1	1.2	24.6	9.3	19.2	1.9
Italy	43.5	4.0	10.6	2.0	29.3	6.1	12.5	3.9
Japan	36.4	3.3	8.8	2.7	31.2	9.7	4.7	4.5
Netherlands	28.4	2.9	6.8	1.0	17.8	1.7	27.6	2.8
Sweden	29.4	.9	5.1	1.0	12.7	2.8	3.9	.7
United Kingdom	34.1	2.3	2.9	.4	32.7	9.2	8.0	.8
United States	19.3	1.6	3.3	.5	22.8	9.8	22.4	7.0
West Germany	31.9	3.4	3.9	.9	25.8	5.6	3.6	.7

Sources: (*9, 12*).

In table 1, CONS represents the private final consumption expenditures on food, beverages, and tobacco at current prices as a percentage of private final consumption expenditures at current prices. PROD represents the domestic product of agriculture, hunting, forestry, and fishing industries at current prices as a percentage of gross domestic product in purchasers' value at current prices. IMPORTS represents total agricultural product imports as a percentage of total merchandise imports. EXPORTS represents total agricultural product exports as a percentage of total merchandise exports. Table 1 presents the mean and standard deviation of the annual measures of agriculture's relative performance.

Consumption of agricultural products accounts for 20-40 percent of total consumption. For several countries, agricultural trade represents over 20 percent of total trade. Agriculture tends not to be as important a part of production in developed countries as in developing countries; however, the importance of agriculture is relatively high in the consumption or trade categories of developed countries. Any sector that consistently contributes over 20 percent of the total—be it production, consumption, or trade—probably warrants separate attention in any modeling effort that attempts to provide sectoral disaggregation. Thus, all the countries listed in table 1 could benefit from including an agricultural sector in their macroeconomic models.

The Agricultural Specification of Macroeconomic Models

In this section, I survey several operational macroeconomic models. I review the equation specifications to determine what agricultural sector variables (endogenous or exogenous) were included in the models and how the agricultural sectors were specified. Only recently could a researcher conduct such a survey. The survey's success hinges on two events: (1) widespread acceptance of the models and (2) adequate documentation.

Although macroeconomic models have existed for many years, only recently have they moved from the position of academic exercises to that of acceptance as relevant forecasting and policy tools which are regularly used. Even after macroeconomic models were accepted and used, many remained solely aggregate national account models. Only recently have some of these models been expanded to the point that they actually contain sectoral details which are endogenously determined.[2]

Many of these models were developed or were improved by commercial econometric modeling firms. These firms have a vested interest in keeping their model specifications a "black box," at least for anyone who is not a customer. This phenomenon, coupled with the general problem of the extremely low priority of detailed documentation for "others," has made this type of equation-by-equation review very difficult—until recently.

The publication of *The Models of Project LINK* (*20*) has made available the detailed model specifications for a series of macroeconomic models. Not only is the LINK model an operating world model, but each country model in LINK is also an autonomous operating model in the country it represents. These LINK models can give us some idea how macroeconomic models in different countries have treated agriculture. Wherever other models were available, I have also reviewed them.

Project LINK

Project LINK is a cooperative, international study group that manages the development and operation of a world macroeconomic model. The Project LINK world model consists of a set of individual country macroeconomic models linked together through a world trade market-share matrix. For each country model, it is assumed that export volumes and import prices are exogenous and that import volumes and export prices are endogenous. The world trade market-share model component, through the world trade identities, determines that export volumes and import prices required for the solution of the individual country models. Thus, through the world trade market-share component, the Project LINK model becomes one large simultaneous world model (*1*, *16*, *20*).

Table 2 summarizes the Project LINK macroeconomic models as they existed in the fall of 1973 (*20*). The appendix summarizes the specific structural specifications of the individual country models in the Project LINK model system.

Most of the smaller Project LINK country models contain no agricultural variables—Belgium, the Netherlands, Developing America, Developing South and East Asia, Developing Middle East plus Libya, and Developing Africa minus Libya. France has only one exogenous agricultural variable.

Five of the country models—Australia, Austria, Canada, Japan, and the United Kingdom—contain endogenous agricultural variables that become components of aggregate national account variables, such as gross national product (GNP) and/or total trade. In none of these five cases is there any feedback from the national account variables to the agricultural components. The specification is strictly a recursive one.

The Australian model determines gross national farm product, which becomes one component of GNP. The Aus-

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[2] For an excellent description of the genealogy of macroeconomic model development in the United States, see (*10*).

Table 2—Comparison of agricultural with total variables in the Project LINK modeling system

Country	Total model					Agricultural component				
	A priori and definitional equations	Stochastic equations	Total equations or endogenous variables	Exogenous variables	Total variables	A priori and definitional equations	Stochastic equations	Total equations or endogenous variables	Exogenous variables	Total variables
					Number					
Australia	41	42	83	78	161	1	0	1	6	7
Austria	83	54	128	42	170	0	2	2	3	5
By count[1]	83	45	128	47	175	—	—	—	—	—
Belgium	6	19	25	20	45	0	0	0	0	0
Canada	139	44	183	126	309	8	0	11	15	46
By count[1]	169	45	214	146	350	—	—	—	—	—
Finland	84	60	144	67	211	8	13	21	7	28
France	13	19	32	29	61	0	0	0	1	1
West Germany	87	51	137	11	148	0	3	3	1	4
By count[1]	77	50	127	22	137	—	—	—	—	—
Italy	51	53	104	60	164	0	1	1	3	4
Japan	35	43	78	41	119	1	3	4	2	6
Netherlands	74	13	87	64	151	0	0	0	0	0
Sweden	58	75	133	97	230	0	5	5	2	7
United Kingdom	120	106	226	135	361	0	3	3	2	5
United States	137	70	207	121	328	4	1	5	8	13
Developing America	1	11	12	6	18	0	0	0	0	0
Developing South and East Asia	1	13	14	6	20	0	0	0	0	0
Developing Middle East plus Libya	1	9	10	5	15	0	0	0	0	0
Developing Africa minus Libya	1	10	11	6	17	0	0	0	0	0
Project LINK system	932	691	1,613	914	2,528	22	31	56	50	106
By count[1]	952	683	1,635	950	2,571	—	—	—	—	—

— = Not applicable.

[1] The summary of the Austrian, Canadian, and West German models in (*20*) gives a different number of equations and variables than are observed from a detailed review of the variables and equation lists. Both sets of numbers are reported in this table. The agricultural component count for Canada also shows an inconsistency. Three endogenous and four exogenous variables defined in the variables list do not appear in any of the reported equations.

trian model endogenously determines agricultural import quantities and export prices, which in turn help determine the value of agricultural imports and exports. These then become components of total imports and exports. Canada has the second largest agricultural block in Project LINK with 26 variables. However, most equations are definitional and are used to determine agricultural investment and agricultural labor income, which become components of GNP. Canadian exogenous wheat exports become one component of total exports. The Japanese model determines agricultural investment, which becomes a component of total investments, which in turn is used to estimate GNP. GNP is used to determine total consumption, which helps determine food and feed imports. Food and feed imports then become one component of total Japanese imports. In the U.K. model, an agricultural contribution to tax receipts is estimated and aggregated with others to obtain total tax receipts. Tax receipts then become part of GNP. Agricutural imports also become one component of total imports.

In two of the above countries, Canada and Japan, additional agricultural variables are functions of aggregate income variables. These are component disaggregations. The specification is still a recursive one. The only difference is that these equations must be solved after the simultaneous solution of the national account variables rather than before; that is, they are post-simultaneous equations rather than pre-simultaneous equations.

Five of the country models—Finland, Italy, Sweden, the United States, and West Germany—have agricultural variables that are integral parts of the simultaneous equation blocks that determine the aggregate national account variables. In these five country models, feedbacks exist between agricultural and nonagricultural variables.

In the U.S., West German, and Italian models, this feedback mechanism works through the trade sector. Food imports represent one component of total imports, which helps to determine aggregate income, which in turn helps directly or indirectly to determine food imports. The U.S. model has a second feedback loop operating through the farm inventory investment/total investment/GNP/inventory deflator/farm inventory investment cycle. The Finnish model's feedback mechanism works through a wages and salaries block. Wages help determine income; which determines total consumption, investment, and trade; which determines agricultural production and, therefore, agricultural labor input requirements. These in turn determine agricultural wages, which become one component of wages and salaries to complete the feedback loop. The Swedish model builds the agricultural sector/national account feedback loop from the production side. Total production helps determine disposable income, which helps determine food consumption, which helps determine food production, which in turn is part of total production.

Although the U.K. model as a separate model has no feedback loops between agricultural and national account blocks, the situation changes when it becomes a part of the Project LINK world model. In the Project LINK system, a feedback loop exists. One determinant of agricultural import prices is U.K. exports. Agricultural import prices help determine food imports and, therefore, total imports and GNP in the United Kingdom. Through the Project LINK trade mechanism, the U.K.'s GNP affects world trade patterns and, therefore, U.K. exports.

A similar situation exists for Austria and Japan. When these two models become a part of the Project LINK system, a feedback loop is created. The loop in these countries is through world trade variables affecting domestic income and, therefore, consumption, which helps determine these countries' agricultural imports, which are a component of these countries' total imports.

Even when the agricultural variable levels are simultaneously determined with the other variables, the specifications of the agricultural sectors can be characterized as fragmentary. Not enough of the agricultural sectors are specified to provide a reasonable view of agricultural behavior.

Chase International Model

The Chase Econometric Associates, Inc. (CEAI) international model (*3, 4, 5, 18*) consists of linked macroeconomic models for Canada, Japan, the United Kingdom, the United States, Germany, France, Italy, Belgium, the Netherlands, Spain, Mexico, and Brazil. All these models are small, aggregate national account models with no sectoral detail. An outline of the Brazilian model shows exports by industry with traditional fish and agricultural products separated into coffee, soya, and other products. However, the equation book and forecast model manual I saw showed no disaggregation of Brazil's exports. Recent forecast reports do show separate agricultural and trade forecasts for both Brazil and Mexico, but they do not indicate whether these variables are endogenous or exogenous.

Economic Models International Models

The Economic Models, Ltd., international models (*7, 8*) are also relatively small, aggregate, national account, macroeconomic models that contain no agricultural variables. Countries modeled include Belgium, France, Germany, Italy, the Netherlands, the United Kingdom, Japan, and the United States. This company was recently sold to Data Resources, Inc. Data Resources announced that these models would serve as the basis for the expanded Data Resources, Inc., international forecasting service.

DRI International Models

I have not seen the detailed specifications of the Data Resources, Inc. (DRI) international models; however, I understand they are also small, aggregate, national account models without agricultural variables.

Evans Economics International Models

The Evans Economics, Inc., international models are also relatively small, aggregate, national account, macroeconomic models. Countries modeled include Australia, Belgium, Canada, France, Italy, Japan, the Netherlands, Switzerland, the United Kingdom, and West Germany. Only the Canadian model contains any agricultural variables—farm income and a producer price index for agriculture. Both are exogenous (*6*).

WEFA International Models

The Wharton Econometric Forecasting Associates, Inc. (WEFA) international models are relatively small, annual, aggregate, national account, macroeconomic models (*21*). Although I have not seen the equation books, I understand that all the national model specifications are similar. The closest thing to an agricultural variable seems to be the forecasts for exports and imports of primary goods. A prospectus indicates that models are operational for Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom, the USSR, Yugoslavia, Argentina, Brazil, Canada, the United States, Iran, Saudi Arabia, South Africa, Turkey, Australia, China, Japan, Korea, New Zealand, Taiwan, the Developing Countries, and the Centrally Planned Economies. WEFA staff say that they plan to disaggregate the Developing Countries region into several medium-sized macroeconomic models soon. They indicate that these models will be supply-oriented models and will include both agricultural and nonagricultural production functions. WEFA indicates that a major goal is to keep the models relatively small. Therefore, they have no plans to incorporate agricultural sector detail into these models.

Macroeconomic Models of the United States

Three of the major macroeconomic models of the U.S. economy are those developed by CEAI, DRI, and WEFA. The Mark III version of the WEFA model has already been reviewed as the Project LINK U.S. model. One evaluation of the models concluded that "... the WEFA model is the only one with a definable agricultural sector. In CEAI, the agricultural sector is subsumed in the 'all other industries' categories while in DRI, the only agricultural variable endogenously determined is proprietors' income, estimated as a reduced form equation of producer level prices received and paid by farmers" (*13*, p. 2).

Roop describes the WEFA model's agricultural sector in the following manner:

> Since the Wharton model has an agricultural sector, the linkages to the remainder of the economy are fairly well developed. Output originating from the agricultural sector gets combined with outputs from other sectors to generate total supply—which is then reconciled with GNP calculated from the demand side. Similarly, the wage bill, proprietors' income, and investment in the agricultural sector are added to those items from other sectors to produce total wages, total investment and total proprietors' income (*14*, p. 14).

Roop and Zeitner provide an equation-by-equation summary of the specification of the Wharton Mark IV agricultural sector:

> Five behavioral equations in Mark IV describe economic activity within the agricultural sector. Fixed nonresidential agricultural investment (IAAG) is determined by the ratio of the implicit price deflator for agricultural output to the user cost of capital, a distributed lag of past output, and lagged value of the estimated error (Cochrane-Orcutt technique). Output originating in agriculture (XAG) is determined by only one explantory variable, personal consumption expenditure for non-durable food and beverages. The implicit deflator associated with XAG (PXAG) is determined by prices received and prices paid, both taken as exogenous. Compensation per man-year (WRCAG$) is determined by distributed lags of three explanatory variables, the potential unemployment rate (CVWNRUT), the consumer price index (PC*), and the ratio of output to agricultural employment (XAG/NEHA). The ratio of proprietary farm income (YENTF$) to the current value of agricultural output is explained by the ratio of prices received to prices paid (PFR* and PFPC*, both exogenous variables).
>
> The linkages of the implied agricultural sector with the rest of the economy are both direct and indirect. Farm investment and the change in farm inventories (IBIF, considered exogenous) in real terms are elements of aggregate investment demand, a component of real gross national product (GNP). Output originating in agriculture is added to other industry outputs and reconciled with the GNP. After prices are computed, including the implicit deflator for agricultural output, the current value of GNP is determined. National income, including proprietary farm income, is calculated by an identity relation that includes

> the wage bill in agriculture. Farm prices received enter directly into the determination of the unit value index of food exports (PTEEGDF) and the change in the wholesale price index of crude materials (PWPC*). In an indirect fashion, the implicit sector deflator (PXAG) enters into the determination of most other implicit deflators. All the implicit deflators for the components of aggregate demand are estimated as a ratio to weighted averages of the industrial sector implicit deflators, the weights having been derived from a separate input-output study. Thus, a current quarter increase in PXAG will enter into the determination of most other prices in the same quarter (*15*, p. 117-18).

Each of these three firms has also constructed separate, agricultural sector models that contain considerable commodity detail. These firms contend that agriculture can be more adequately handled via these separate modeling efforts. They say that although the models are separate, the models could be solved in an iterative fashion with forecast values passed from one model to the other until a consistent forecast is obtained from both models. Although this approach would work in theory, I suspect these firms seldom, if ever, operate their models in this manner. In fact, given the specifications Roop reported, there are so few agricultural linkage points in the macroeconomic models that, even with this iterative procedure, little feedback is possible.

Conclusions

Agriculture is an important sector of the national economy. The general trend in macroeconomic modeling tends to be toward increasingly detailed models, and agriculture is a logical area of interest.

The agricultural sector is generally ignored or is treated exogenously by model builders. When the sector is treated endogenously, the specification is far from satisfactory from the viewpoint of an agricultural economist. Agricultural economists would criticize most endogenous agricultural sectors as being structurally misspecified and/or as too small to provide relevant information about agriculture to agriculturalists. Because of this, simulation results from agriculture/nonagriculture policy shocks have little credibility, particularly with agricultural economists.

Agricultural economists look at agricultural issues. Perhaps this has caused general economists to overlook the agricultural block when incorporating sectoral detail into their models. Economists may have assumed that, as agricultural economists were modeling the agricultural sector in detail, they could treat agriculture as exogenous. However, as Subotnik (*19*) indicates, agricultural economists are not incorporating this area of agriculture/nonagriculture linkages into their operational models either.

Work in this area will soon run into methodological problems. Macroeconomic models have been built with macroeconomic methods, whereas agricultural commodity models have been built with microeconomic methods. Macroeconomics starts from the viewpoint of aggregate economic behavior and attempts to model this aggregate behavior directly. Microeconomics starts from the viewpoint of the individual and attempts to explain why individuals behave the way they do. Market phenomena are explained by an aggregation of individual behavior. In one case, aggregate agricultural sector behavior is arrived at through a thought process involving aggregation. In the other case, it is arrived at through a disaggregation process. As they start from different world views, these two processes may not reach the same, or even compatible, positions. Incorporating agriculture into macroeconomic models may involve using macroeconomic methods in the construction of the agricultural component. This may require focusing less on supply/demand type commodity models and more on aggregate farm account, production process, and agricultural consumption function models that can be integrated into the existing macroeconomic models more directly. In fact, the existing, detailed, microeconomic, supply-demand agricultural commodity models may be more easily linked to macroeconomic agricultural components than to the existing, national account, macroeconomic models. Conceivably, the proper approach to developing feedback loops between agriculture and the rest of the economy may best be achieved indirectly. Instead of directly linking macroeconomic models to commodity models, it would be preferable to link the models indirectly—that is, from macroeconomic to macroeconomic agriculture to commodity models. This may prove the most fruitful approach to modeling this agriculture/nonagriculture interface.

No matter how this question is finally resolved, the first prerequisite is for people to work on the problem. The economics profession (both general and agricultural) does not yet have even that. Given the increased interest in, and the importance of, agriculture, I should think the return on work in this area would be quite high.

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Appendix: A Summary of Project LINK Country Model Agricultural Sectors

Australia

There are seven agricultural variables in the Australian model. Only one is endogenous, and it is a product of two exogenous agricultural variables (when gross national farm product is defined as gross national farm product at 1966 prices times the price deflator for gross farm national product.)[3] This model is generally defined in terms of national account variables by major sectors. The exogenous agricultural variables defined here provide one component of a sum used to calculate aggregate national account variables.

Austria

There are five agricultural variables in the Austrian model. All are included in the trade sector only. Two are endogenous—imports of SITC 0 + 1 goods and SITC 0 + 1 export price index. Imports of SITC 0 + 1 goods are specified as a function of private consumption of nondurables, GNP of the agricultural sector, and lagged imports of SITC 0 + 1. The SITC 0 + 1 export price index is a function of time, the total demand price deflator, and the lagged SITC 0 + 1 export price index relative to the total demand price deflator. These two endogenous variables are then combined with the exogenous SITC 0 + 1 import price index and the exports of SITC 0 + 1 goods to define one component of total imports and exports.

Belgium

No agricultural variables are included in the Belgian model.

Canada

There are 26 agricultural variables, 11 of which are endogenous, in the Canadian model. These include variables dealing with agriculture, fishing, and/or trapping. Of those defined in the variables list, four endogenous variables and four exogenous variables are not listed in the model equations. All endogenous agricultural variables are definitional in nature.[4] The agricultural variables are concentrated in the foreign trade, investment/capital stock, employment, and production blocks. The latter three blocks feed the income block.

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[3] This definitional equation and variable are not listed in the equation or in the variable list; however, the variable is used in another definitional equation.

[4] Of the four unexplained endogenous variables, three are definitional. Employment in agriculture, fishing, and trapping is undefined.

Two exogenous agricultural variables in the foreign trade block—wheat export quantities and wheat price—determine the value of wheat exports. Wheat exports then become one component of total merchandise exports.

The investment/capital stock block includes several exogenous agricultural investment components that are used as components in calculating GNP. These investment variables, along with initial capital stock levels, are used to generate future capital stock levels and thereby the capital/output and capital/labor ratios for agriculture.

The employment block variables consist of exogenous agricultural wage rates and endogenous employment that determine labor income in agriculture, which becomes one component of total labor income.

The production block consists of exogenous estimates of real gross domestic agricultural product and the implicit gross domestic product (GDP) price index for agriculture which are used to calculate agricultural output, which in turn affects corporate profits and ultimately components of national income (net national income itself is based on adjusted GNP).

Thus, agriculture in the Canadian model is essentially exogenous and is used to provide components of aggregate variables, whereas the other sector components are endogenous. There is no feedback from the nonagricultural sectors to the agricultural sector in this model.

Finland

The production, employment, price, and income components of the Finnish model have been disaggregated into agriculture, noncompetitive industries, forestry, and competitive industries sectors. Of the 28 agriculturally oriented variables in the model, 18 (6 are exogenous) are in the agricultural sector and 10 (1 is exogenous) are in the forestry sector.

The production-employment-price-income component of the agricultural and forestry sectors are similarly defined. Each sector component is essentially driven by three variables—sector input prices, sector prices, and sector production. Sector prices are exogenous whereas sector input prices are a function of raw material prices, fuel and lubricant prices, and time. Sector production is a function of total consumption, total investment, total exports, total imports, inventory change, and time. These variables determine sector production at factor cost and then nonwage income for the sector. Prices and production in the sector also generate labor inputs and wage rates in the sector. These in turn yield sector wages and salaries and sector social security payments. Each of these measures in turn becomes a component of total wages and salaries, total social security payments, total disposable income, and GNP.

France

The French model contains one exogenous agriculture variable—employment in agriculture. The percentage change in total employment is partly a function of the percentage change in agricultural employment.

Italy

There are four agricultural variables in the Italian model. Only the value of agricultural imports is endogenous. Agricultural imports are a function of the three exogenous variables—the gross agricultural product, the wholesale price index of agricultural products, and the unit value index of agricultural imports—plus private consumption, the exchange rate, and quarterly dummies. Agricultural imports then become one component of total imports. The unit value index of agricultural imports becomes one component of the import price index. The wholesale price index of agricultural products and gross agricultural product, respectively, are used to derive a general index of consumer prices and gross product in the services sector.

Japan

The Japanese model contains six agricultural variables. Two are exogenous—real agricultural inventory investment and the implicit price deflator for agricultural inventory investment. These variables are used to determine total investment, and then GNP, national income, and consumption. Consumption, in turn, determines real food and feed imports, which then become a component of total imports. Employment, wages, and wages in agriculture determine self-employment in agriculture, and then unemployment as a residual. The product of agricultural wages and self-employment in agriculture also determine agricultural income. Self-employed nonagricultural income is calculated as a residual. The agricultural variables are used to provide disaggregated component forecasts, but they do not provide feedback for determining the aggregate national account variables.

Netherlands

There are no agricultural variables in the model for the Netherlands.

Sweden

The Swedish model contains five endogenous and two exogenous agricultural variables.[5] The model's agricultural block centers on the forecast of food consumption. Food consumption in turn is used to forecast food production, food imports, and the SITC 2-4 category imports. Food consumption also provides one component of total private consumption and, therefore, GNP. Food production then determines sales of industrial products and raw material food inventories, and it provides one component of total mining and manufacturing production. Total inventory stocks are determined partly by total mining and manufacturing production, raw-material food inventories, and finished-goods food inventories (which are a function of total private consumption). Total mining and manufacturing production affects disposable income, which in turn affects food consumption. The two exogenous variables, controlled agricultural prices and agricultural inputs to the chemical industry, respectively, help determine that industry's disposable income and its sales of industrial production.

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[5] The Swedish model contains an additional 12 endogenous and 4 exogenous variables in the wood and pulp, paper, and paperboard industries.

United Kingdom

There are three endogenous and two exogenous agricultural variables in the U.K. model. Agriculture enters the model in two areas. First, the consumption of nondurable goods and the discretionary change in beer, wine, spirits, and tobacco duties determine the level of duties on beer, wine, spirits, and tobacco. These in turn provide one component of tax receipts. Second, the exchange rate, world export prices, and world exports of manufactures determine the unit value index for imports of food, drink, and tobacco. This price variable (deflated), time, two strike dummy variables, and a food import fluctuations dummy variable are used to calculate the level of imports of food, drink, and tobacco. This import variable and the import unit value index in turn become components of total imports (both quantity and value).

United States

There are eight exogenous and five endogenous agricultural variables in the U.S. model. Most of the agricultural detail in this model is in the investment sector. Real farm business inventory investment is defined as the change in the exogenous farm inventory stock. This becomes a component of total real inventory investment and—along with the exogenous implicit deflator for gross product originating in agriculture, forestry, and fish—defines current-dollar farm business inventory investment and then total current-dollar inventory investment. Real investment in farm structures is exogenous. Along with the implicit deflator for fixed investment in farm residential structures, it determines nominal farm residential structures investment and then total residential investment. The two investment figures in turn help determine GNP. GNP and the exogenous gross product originating in agriculture, forestry, and fisheries define gross product originating in commercial and other industries. This variable then helps determine the nonfarm, residential structures, investment deflator. The ratio of the farm, residential structures, investment deflator to the nonfarm, residential structures investment deflator in period t is the same as in $t-1$, thus making the farm deflator a function of the nonfarm deflator.

The exogenous agriculture, forestry, and fisheries employee compensation is one component of total employee compensation. This, along with GNP, helps determine corporate profits.

Food imports are a function of disposable income, a dock strike dummy variable, and three exogenous agricultural variables—the food import price, the consumer food price index, and a Brazilian coffee crop failure dummy variable. Food imports and food import prices then become one component of both real and nominal total imports, which in turn helps determine GNP.

The agricultural sector of the U.S. model can, therefore, be seen as essentially exogenous to the overall model structure.

West Germany

There are four agricultural variables, three of which are endogenous, in the West German model. All are in the trade sector. Retail food prices determine the quantity of agricultural imports, which in turn becomes one component of total import quantities. These import quantities, combined with the exogenous agricultural import price, determine the value of agricultural and, therefore, total, imports.

Developing America

There are no agricultural variables in the Developing America regional model.

Developing South and East Asia

There are no agricultural variables in the Developing South and East Asia regional model.

Developing Middle East plus Libya

There are no agricultural variables in the Developing Middle East plus Libya regional model.

Developing Africa less Libya

There are no agricultural variables in the Developing Africa less Libya regional model.

Spatial Aspects of Rural Development

By Clark Edwards*

Abstract

Traditional economic theory has ignored the spatial aspects of rural development. This article reviews literature which focuses on the functional relationships between geographic space and rural development. Spatial considerations affect the size and location of individual firms. They also affect geographic patterns of economic activity and the formation of regions. Three empirical approaches to regionalization are reviewed—administrative, homogeneous, and functional. Rurality is defined according to concepts of central place, hinterland, and hierarchy. Much of the literature of regional economic development represents an urban point of view, but some represents a rural point of view and indicates that the development of a rural area depends partly on factors affecting location and regionalization.

Keywords

Rural economic development, Growth, Location, Region

Rurality is partly a geographic concept. Rural places can be located on a map, and rural development is a spatial phenomenon. This much follows by definition. Because of the formal connection between rural development and geography, it is somewhat surprising that functional or behavioral connections between development and space are so often overlooked in the literature.

It is fair for Siebert to say that "traditional theory has long ignored this spatial aspect of economic behavior" (*79*, p. 1). Jutila adds, "an economic model should be subject to an extension by exogenous introductions of such dimensions as space, distance, and location" (*46*, p. 95). Isard and Liossatos refer to the omission of spatial considerations when they observe "that there exists a major gap [which] pertains to development theory, growth theory, evolutionary theory, theories of transition and change (cyclical and secular), and in general, dynamic social theory" (*42*, p. 9).

The purpose of this article is to review some of the literature which relates geographic space to economic development—and to rural development—and to persuade the reader that the character of economic development in rural areas is strongly, although not solely, influenced by spatial factors.

The importance of space in economic development has never been totally ignored. Smith (*80*) and Ricardo (*71*) recognized the role of spatial location in rent theory; Smith devoted considerable attention to the differential influences of town and country on the wealth of nations; and von Thunen (*106*) developed his seminal approach to the location of economic activity more than a century and a half ago. Although spatial aspects of economic development were included when the discipline of economics was founded, these aspects were lost sight of in mainstream theory and practice for about a century.

Efforts early in this century to include locational information in economic analyses were largely descriptive. For example, Taylor (*91*) included the geographical method in his list of five methods used in agricultural economics research. His geographical method was to arrange on maps large quantities of data collected by the Bureau of the Census and by market reporting agencies.

Spatial economics is largely a post-World War II phenomenon (*30*, pp. 7-8) for which the underpinnings were laid during the previous two or three decades. Two books by Isard (*39*, *40*) were of paramount importance in expanding these beginnings into a discipline which is helpful in explaining the functional relationships between geography and economic development.

"Growth occurs in space," says Siebert; "it is influenced by the spatial structure and it has a feedback upon the economic landscape" (*79*, p. ix). Efforts to study these feedbacks have sometimes suffered for want of a consistent theoretical approach. Kerr and Williamson note that "regional economists have borrowed theories, principles, and analytical tools from general economics and adapted them for their own specific purposes" (*48*, p. 6).

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Subregional development is a function of national development, according to Cumberland: "Disaggregation of national experience by space is as essential as disaggregation by time and by industry in advancing understanding of the phenomenon involved" (*18*, p. 1). That is, the parts are explained in terms of the whole.

Others turn the logic around and explain the whole in terms of its parts. Richardson explains the bottom-up mechanism involved in relating geographic to economic space: "Growth rates vary with location over time because the relative strength of agglomeration and dispersion factors alters over space and inter-temporally" (*73*, p. 2).

Policy implications of space are emphasized by Friedman and Alonso: "The decision about how much of a given resource to allocate to a specific function must ultimately involve the question of where this allocation is to take effect, if only because its contribution to national economic growth will tend to vary greatly with location" (*25*, p. xv).

Recently, progress has been made in integrating spatial theory with static economics; integration with dynamic economics is still incomplete (*41*, *42*). Richardson's model (*72*) is based on the neoclassical equilibrium framework that, by itself, neglects spatial factors affecting economic development. He seeks to incorporate in this model the spatial effects of diffusion, agglomeration, and cumulative causation. Richardson (*73*, pp. 5-6) explains why the attempt at integration will likely remain incomplete: the spaceless neoclassical model has certain implications which conflict with spatially explicit formulations of the development process.

Borts believes of Richardson (*72*) that "what started out as an attack on neoclassical growth models winds up as an interesting, potentially testable, and useful synthesis of locational variables which might strengthen the neoclassical approach" (*10*, p. 546). Borts notes that the model Richardson (*72*) presents at the end of his book embraces "precisely those neoclassical relations spurned at the beginning" (*10*, p. 546). Von Boventer comments that Richardson's main thesis is "fully correct . . . that the significance of neoclassical adjustment mechanisms has, on the whole, been overrated and that cumulative processes and agglomeration factors should be given much more attention than has been the case in the past" (*105*, p. 2).

Spatial studies may take the microscopic view of where one added firm would locate, if everything else were in place, or they may take the macroscopic view of the spatial pattern of all economic activity. The next section reviews selected literature pertaining to the location of individual firms, households, or projects. This points to one of the unique contributions of regional economics—the importance of spatial relationships in economics. Following that is a review of spatial patterns. This points to another unique contribution—the concept of a region as a unit of analysis. The remaining sections turn to rural development matters such as growth center strategies and rural-urban balance.

Individual Location

The theory of location of an individual firm generally assumes a profit-maximizing firm with perfect knowledge in a free market (*1*). Most firms respond to specific locational influences. For example, those with relatively high transportation costs locate to minimize such costs, and those with high labor costs are labor oriented. Some firms respond to more than one locational influence; the profit-maximizing location may be based on marginal tradeoffs between, say, labor and transportation costs. Some firms have no particular locational orientation and are called footloose.

Transportation costs tend to concentrate industries; a new plant tends to locate near existing ones because of its orientation toward resources, markets, junctions, transshipment points, or median locations. Avoidance of high rent and the hope of establishing a local monopoly are examples of dispersive locational forces causing new plants to decentralize and locate away from existing plants. Thus, the optimal location for some firms is an urban place, whereas other firms fare best in a rural area. This phenomenon applies to farms as well as to nonfarm firms. Truck farms may do best close to markets, whereas cow and calf herds are maintained in distant and open spaces.

Weber (*108*) examined the least-cost location of a firm with respect to regional variation in the cost of labor and transportation. Hoover (*36*) extended the analysis to include other factors and characterized the location of firms relative to inputs or markets with respect to whether production is weight-increasing or weight-decreasing. "Until fairly recently, location theory laid an exaggerated emphasis on the role of transportation costs," according to Hoover (*38*, p. 23).

The spatial dimension was integrated by Isard (*39*) into the conventional theory of the firm. Later extensions showed that one can make serious errors in firm analysis by ignoring nonspatial factors, just as errors were made earlier when spatial ones were ignored. Greenhut (*31*) summed it up by observing that longrun competitive equilibrium in the space economy simply requires that marginal cost equal marginal revenue and that average cost equal price in spatial as well as in nonspatial dimensions.

Complete integration of spatial with nonspatial economics is not so simple as it first appeared. For example, equilibrium models are hard to build because the relationship of information to distance makes it difficult to assume perfect knowledge and because recognition of spatial monopoly makes it difficult to assume perfect competition. However, these efforts show that one needs to take geographic space into account when analyzing the economic behavior of firms, households, and government projects.

Useful variations of location theory result from relaxation of assumptions about the goal (*12*, chaps. 1 and 2; *39*, p. 221), about knowledge (*107*), and about the market structure (*31*). The objective to be maximized is usually assumed to be one held by the firm manager. When the viewpoint of society is taken instead, a different location is likely to be optimal; the profit-maximizing location of a plant may not be the optimal site from the perspective of access to jobs by residents of a depressed region. An externality from the point of view of management may be internal from the point of view of labor.

Business activity tends to become more concentrated when there is uncertainty about spatial relationships. Webber (*107*) drew upon game models, probability models, and hypothetical simulations in his discussion of the relations between space and uncertainty. Firm managers' uncertainty about markets, sources of supply, and levels of productivity, says Webber, tends to send them to the obvious, or safe, location—the center of the market. This location may not be optimal, given complete knowledge. Uncertainty can raise distance costs, increase inventories, reduce the size of plants, and increase external economies of scale. Innovation is thought to be more probable in a concentrated area; and diffusion processes, or learning curves, may result in accelerated growth in concentrated areas relative to remote, sparsely populated areas. Thus, uncertainty about spatial relationships tends to concentrate and urbanize plant location beyond what would be socially optimal under conditions of perfect knowledge. Reduction of uncertainty through communication and planning may lead to a less concentrated, more rural-oriented society.

Economic and social characteristics of a region affect the likelihood that an economic activity will locate there. Spiegelman (*84*) regressed the growth during the 1947-58 period of 53 manufacturing industries in 506 multicounty areas of the United States on 75 local explanatory economic and social characteristics. He found, for example, that the industry manufacturing upholstered, wood, household furniture (SIC-2512) grew the fastest in areas with a small proportion of prosperous farms, a large proportion of lower-income farms, and low building construction costs.

Regional variations in tax structure affect growth according to Struyk (*86*, *87*). He argued that "there is an inverse relationship between growth and degree of taxation." Hady (*32*) is representative of the more popular view that there is little relationship between regional growth and the local tax structure. Kaldor (*47*) concluded that higher taxes can destroy incentives to locate firms, but can also be spent in a way that will enhance available resources and promote development.

The location of a plant in a specific region affects the prospects for further change. The relationship of an individual plant location to economic development is usually seen through multiplier analysis. If a locality creates the economic conditions that attract firms, then the locality will grow, not only by the direct attraction of more firms but also by the indirect multiplier effect on related jobs and income. Regional development practice has concentrated on industrial plant location because of the assumed "growth generating nature of manufacturing" (*57*).

The impact on a local economy of a new plant is variable. Sometimes there is a strong, positive multiplier (*59*), sometimes a small one (*45*); sometimes the longrun impact is negative (*27*). When a new plant fails, it can leave a rural area with more unemployment than before the plant was moved in (*17*). Some of the variation in multipliers has been explained by variation in type of industry, scale of industry, and location of a plant relative to a regional trade center (*3*, *4*).

Approaches to Regionalization

In much of the literature on economic development there is confusion about what it is that changes—that is, "What is a region?" A region is sometimes understood to be a contiguous and bounded geographic space delineated for a purpose. This definition is broader and looser than one drawn directly from considerations of transportation and central place; however, it is useful for following the theory and practice of delineating regions in a country like the United States.

Three procedures for delineating regions have been recognized: administrative, homogeneous, and functional (*11*). An administrative region is a legal one designed to implement decisions. States and counties are administrative regions; so are cities. A homogeneous region is one whose internal elements are statistically similar to one another and dissimilar from those of other regions. For example, one rural region might be delineated as homogeneous with respect to corn production and another as homogeneous with respect to wheat. Farms within each region are somewhat like one another, but farms in different regions are unlike. A functional region is comprised of a central place and its hinterland that function together as an economic unit. A functional region is generally heterogeneous with respect to the criteria used to delineate homogeneous regions. The homogeneity in this case is with respect to internal economic function.

Administrative Units

The primary purpose of an administrative region is political. However, once political units such as States, counties, and municipalities are delineated, they prove to be convenient units for describing and analyzing economic development. There are some references in the literature to interjurisdictional units composed of several counties or of several States, and numerous references to communities.

Gilbertson noted, "the counties were derived originally for communities in a state of nature—few people widely scattered, all but oblivious to the existence or need of government" (*29*, p. 171). He argued that the cities which became functional units were those that saw the need for local rule and usurped some of the functions of county government. Counties tended to defend themselves against the cities at some point short of annihilation, and we now have both types of government operating, often with duplication, at the local level. Gilbertson (*29*, p. 152) cited the *New York Times* as having proposed in 1915 to abolish existing boundaries of the New York counties and substitute 8 administrative districts. He traced why these consolidation efforts, however logical they might be, will generally fail (*29*, p. 152). In fact, history was moving in the opposite direction; a 62nd county—the Bronx—was created out of New York county in 1914.

A multicounty structure is sometimes superimposed on the county structure for political convenience. Multicounty coalitions usually are formed for special purposes, such as coping with interjurisdictional matters related to health, transportation, water, air, or natural resources. The multicounty structure for political, administrative purposes that comes closest to blanketing the entire United States was one promulgated by the U.S. Office of Management and Budget (OMB) (*101*) through its circular A-95.

A report by the U.S. Department of Agriculture (USDA) recommended a regional approach to rural development "which would allow local input in the determination of priorities, yet assure that decisions and funds were all being used toward national goals" (*96*, p. 23). Multistate regional centers are proposed as well as substate multicounty regions. The report says, "one of the most promising approaches is substate districts required by OMB Circular A-95" (*96*, p. 25).

The issue of whether it pays to analyze anything but a political region is raised in a report by the National Academy of Sciences (*65*, pp. 48-49) because it is the only type of region for which leaders can be identified and for which policies can be implemented. The report points out that "in most cases a region is not identified with a specified political unit or governmental body." It suggests that isolating policies to promote regional development in such cases "may be a futile intellectual exercise."

During the sixties, multistate regions were designated that shared problems of economic distress or lag that extended beyond the capability of any one State to solve (*94*). These regions, which were designated by the Secretary of Commerce with the concurrence of the States involved, helped overcome difficulties resulting from the fact that "the region does not have a formal legal place in the political system" (*95*, p. 1). Multistate regions were delineated for Appalachia, the Ozarks, New England, the Four Corners, the Coastal Plains, and the Upper Great Lakes (*102*, *103*). These regional development commissions proved to be useful organizations for coping with interjurisdictional problems that transcend State lines. However, each multistate region was defined in isolation from rather than in relation to economic patterns of the Nation, so the geographic area was unevenly covered despite recent re-delineations and additions. Hansen (*34*) found that the delineation tended to exclude from some of the regions the nearby urban places that could be expected to help solve an economic development problem.

Homogeneous Units

An early example of mapping the country into homogeneous regions is provided by Odum and Moore (*66*). They delineated six multistate regions "approximating the largest available degree of homogeneity measured by the largest number of indices available for the largest possible number of purposes" (quoted in *69*, p. 332). Later, Odum expressed dissatisfaction with using State boundaries to delineate "societal regions" (*69*, p. 332).

Mangus (*58*) used county boundaries to delineate 264 rural cultural subregions with homogeneous economic and social structure. He then combined these subregions into 34 rural cultural regions. Woofter (*110*) superimposed rural industrial activity on Mangus's map and renamed the 34 regions to suggest more of a cultural, and less of a geographic, connotation. Colby, Marschner, and Haggerty used 235 "livelihood areas," which did not follow county boundaries, as units of area analysis (*100*). These areas were then combined into 34 regions approximating those by Mangus.

The value of homogeneous locality units in social science was examined by Raper and Taylor (*69*, p. 339). Lively and Gregory believed that their 16 rural social areas in Missouri, which were delineated according to homogeneity of culture, should be useful "in the administrative analysis of rural social problems" (*55*, p. 1).

One of the explicit purposes for which regions were delineated was to promote national economic development:

> . . . the part of wisdom is to study the local economy of each section of the country. This areal approach is in harmony with the fact that the strength of the nation in peace as in war lies in the effective utilization of all of its resources of men and material (*100*, p. 40).

Bogue and Beale (*9*) subdivided the United States into clusters that were as homogeneous as practical regarding their general livelihood and socioeconomic characteristics and that would utilize available sources of descriptive statistics. They accomplished this by grouping similar counties. The result is 506 State Economic Areas (SEA) covering the entire land area of the 48 contiguous States. The purpose of these economic areas is different from those cited for some of the earlier homogeneous area delineations. In this case, the intention was to provide a descriptively useful way to summarize county data collected by the U.S. Census.

Homogeneous units have proved convenient for descriptive purposes; like things are grouped, and unlike things are separated. However, homogeneous units lack the political cohesion so important for the administrative units. They also lack the unity of economic interdependence that characterizes the functional units.

Functional Units

Von Thunen (*106*) considered a central place with its agricultural hinterlands and examined the spatial pattern of the whole region. Weber (*108*) emphasized the importance of agglomeration economies in plant location. Many subsequent studies of agglomeration have been concerned with spatial concentration of firms in a single industry. But the concept is probably more important for its focus on the economics of spatial propinquity of apparently unrelated industries. Isard, Schooler, and Vietorisz (*43*) extended the agglomerative concept and developed the idea of "industrial complex analysis," which focuses on flows of goods and services among different industries within a region. A consideration of agglomeration turns one's attention to the macrolevel outcome of decisions not only by many firms and households but also by local institutions or groups.

The emergence of rural communities before the automobile replaced the horse and wagon was studied by Galpin (*26*). He delineated 12 trade centers in Walworth County, Wis., that were in stable adjustment to available transportation. Galpin found it difficult, if not impossible, to avoid the conclusion that the limit of the trade zone of one of these rather complete agricultural civic centers formed the boundary of an actual, if not a legal, community. Galpin conceptualized a system of communities formed of trade centers with circular hinterlands of approximately 50 square miles. A system of such communities on a featureless plain would consist of a series of circles, whose outer edges overlapped, and whose trade centers were some 8 miles from one another.

The agricultural hinterland around Louisville, Ky., was examined by Arnold and Montgomery (*2*). They found empirical support for von Thunen's idea that the distance from a city influences the type of farming. Truck crops and potatoes were dominant, close-in enterprises. This was shown to be largely a function of the access of truck farmers to city sources of manure. Field crops like corn, wheat, hay, hogs, and cattle were more important as distance from the city increased. Dairying was also more important with distance. The value of land per acre was shown by Arnold and Montgomery to decrease as distance from the central place increased.

Time had changed the areas Galpin had studied. This was noted by Kolb and Brunner:

> While farmer and villager have united in the building of a larger community, the contacts of both with the city have increased both directly and indirectly. Naturally, therefore, as one observes the pattern of life in concentric zones around the city the old differences between urban and rural begin to fade (*50*, p. 552).

McKenzie added, "Smaller communities within a wide radius of every urban center have lost much of their former isolation, provincialism, and independence" (*60*, p. 443).

Christaller (*16*) was unaware of Galpin's work (*26*) when he introduced central place theory, which incorporated the idea that the economic development of a city depends on its specialization in various functions and on the demand for central city services. Christaller saw a region as composed of a central place and its hinterlands; the economic fortunes of a region depend on the interplay among its parts. He analyzed dynamic processes mainly in terms of comparative statics, although he did pay some attention to technical change and to economic development.

Spatial relationships were studied by Losch (*56*) under assumptions of noncompetitive markets. He extended the analysis to problems of general location patterns and to the network of economic regions. Losch presented a single, geometric basis for unifying spatial arrangements which Christaller had considered independent. The honeycomb pattern of regular hexagons considered by Christaller and Losch as a possible geographical configuration of functional economic areas would have resulted from Galpin's framework, if Galpin had drawn straight lines in his figure 10 to divide equally the overlapping segments of his circular trade areas. Soap bubbles clustered on a plane between two nearly touching plates of glass assume the same efficient, natural, hexagonal structure.

Losch examined economic forces influencing the varied pattern of economic landscapes and showed how the hierarchy of markets is modified by a consideration of administrative needs and cultural factors. Spiegelman (*82*) believed that Losch's work failed to precipitate the anticipated revolution in regional analysis; Meyer (*61*) hailed the work as having given location theory an identity.

These considerations of firm location and agglomeration suggest that regionalization affects economic development. In central place theory, the center and its hinterland are complements. The center provides goods and services to residents of the hinterland, and it offers jobs, shopping, and cultural attractions to commuters or migrants from the hinterland. The hinterland produces rural-oriented goods, like food, textiles, minerals, and timber products, and it furnishes workers to fill central-place jobs. It may supply residential and recreational sites for central city workers. It may also provide sites for decentralization of central-place activities. For example, it may offer a low-rent site to a manufacturing firm that is dependent on the central place for transportation and financial services.

The impact of change in the central place on economic activity in the hinterland may be positive or negative. Miron (*63*) reviews the spread and backwash hypotheses. The spread hypothesis, he says, asserts that outlying areas expand when the center expands; the backwash hypothesis asserts that such areas decline. Miron describes a spatial equilibrium model which incorporates both hypotheses. He explains the spread effect by increased demand and the backwash effect by changes in technology that result in the substitution of more central city resources for fewer hinterland resources (*63*, pp. 151, 152).

For a central place to be formed, some threshold in demand for its services must be reached. Downs (*20*) called this threshold a "critical mass." Demand for central place services increases as the hinterland becomes more densely populated, grows larger, increases income per capita, reduces transportation costs, or experiences a change in tastes. The threshold is much lower for some industries than for others. Until an industry's threshold has been reached in a specific region, that industry will not locate there. The threshold concept is used in central place theory to explain hierarchy of central place, where both smaller villages and larger cities provide goods and services which have lower thresholds, but where only the larger cities provide specialized functions which have higher thresholds.

The conclusion of the regional economist is that functional economic areas, each composed of a central place and its hinterland, are appropriate units of analysis. Homogeneous units are proposed because they have descriptive value, but functional units can also be descriptively useful. However, if the functional units lack political unity, they may be less useful than are administrative units for policy-oriented analysis. A regional system is most useful when a single delineation meets the needs for administration, description, and function.

Empirical Delineation of Functional Economic Areas

The theories of von Thunen, Weber, Galpin, Christaller, Losch, and others suggest that for purposes of describing and explaining economic development, the geography of a nation can be subdivided into a number of regions, each with its central place and hinterland. Since 1961, Fox has written many papers on the concept of functional economic areas (*23*, p. 13). He seeks a practical approximation to the theoretical idea by delineating hinterlands within commuting distance of central places (*22*). Fox (*21; 51*, pp. 163-172) points out that counties may have functioned as units when they were formed, with the county seat within commuting distance by horse and buggy for most residents. However, he says to those who treat a nine-county area in Iowa functioning as an economic unit as if it were nine separate areas: "What the people have put together, let not the politicians and the administrators put asunder" (*23*, p. 22). Fox recommends that the functional economic area concept be used for analysis and for implementation of economic development programs that rely heavily on local initiative and local recognition of mutual interest (*23*, p. 55).

Commuting patterns reported in the *U.S. Census of Population: 1960* were analyzed by Berry (*7*) to establish commuting fields around central cities. He found that 87 percent of the U.S. population lived within the commuting fields of cities exceeding 50,000 people. Another 9 percent lived within the commuting fields of cities with more than 25,000 people. He delineated 305 commuting areas containing 96 percent of the population. The remaining 4 percent lived outside functional economic areas as he defined them.

Rand McNally (*68*) publishes a map which divides the 50 States into 494 Basic Trading Areas. The boundaries of these areas follow county lines and are based on studies of physiography, population, newspaper circulation, economic activity, highway facilities, railroad services, suburban transportation, and subjective field reports from sales analysts. The Rand McNally areas approximate functional economic areas, as do those of Fox, Berry, and others, and they have the additional advantage of blanketing the entire land area of the Nation.

The Bureau of Economic Analysis (*97*) delineated the 50 States into 183 multicounty areas called BEA economic areas (see also *99*). Three basic guidelines were used: (1) include all counties; (2) have regions large enough that estimates of income and other economic and social attributes have statistical reliability; and (3) conform to functional economic area logic to the extent that limited time and research budgets permit. Snead (*81*) described the BEA areas and he discussed many of their analytical and operational properties. He illustrated the suitability of using them in analyzing and implementing Federal programs. These areas are useful units of analysis for many subnational problems, but they are relatively large in terms of trading and commuting patterns.

A statistical analysis indicates that the Rand-McNally areas, the BEA areas, and an additional set known as Basic Economic Research Areas (BERA)—which was worked out by USDA economists—are substitutes for one another to the extent that correlations, regressions, and factor analyses tend to produce about the same results. The statistical properties of the three functional economic areas are different from those of the homogeneous State Economic Areas delineated by Bogue and Beale (*9*) and different from those of administrative areas like counties and States. Their statistical properties are similar, however, to those of the substate planning districts delineated by the governors of the various states under Circular A-95. This result suggests that it is feasible to delineate regions that are functional, political, and descriptive.

Analysis of commuting and trade patterns suggests that the United States is probably composed of some 500 functional economic areas which are relatively closed with respect to trading and commuting. Fox says:

> [Functional economic areas] form areas of very strong common interest with regard to economic development policy. Larger areas would include too many subsets among which economic transactions would either be nonexistent or very remote. Smaller areas would produce a situation with too many issues where the communities of interest would straddle regional borders (*52*, p. 138).

Functional economic areas fit into a hierarchy in which some are fairly rural and can themselves be considered as a hinterland to some of the relatively more urban-oriented multicounty areas which provide central city services to residents beyond commuting distance. About half of the 500 functional economic areas contain one or more cities exceeding 50,000 persons and the other half are relatively rural. Hence, the word "rural" can take on two meanings: (1) the hinterlands of each of the 500 functional economic areas, or (2) the 250 or so functional economic areas that are generally rural in character because they have relatively small cities as a central place.

Growth Centers

Central places perform their centralized functions whether or not they are growing; yet the terms "central place" and "growth center" are frequently used as if they were synonymous. The concept of central place is carefully and consistently defined but the concept of a growth center is not. Some authors apparently use the term to mean any urban place that grew during some recent period. For example, Hansen says, "Growth centers are SMSAs in which population growth from 1960 to 1970 was more rapid than in SMSAs as a whole" (*34*, p. 509). This overlooks that some urban places which grew may have been satellite rather than central places, and that some urban places which did not grow may have been satisfactorily performing their central place functions. Hansen's definition implies that only SMSAs are to be considered as centers, whereas the central places of half the functional economic areas in the United States are smaller than SMSAs. Darwent (*19*) clears up much confusion about the terms "growth pole" and "growth center" (see also *75*, p. 28). Bird (*8*) implies that growth centers which are also central places of functional economic areas have a key role to play in national economic development, and he mentions that national programs are weakened when centers are designated in response to political pressures, community pride, and other considerations.

Some studies suggest that there are diminishing returns (or increasing costs) once a threshold has been reached and that there is an optimal city size (*93*). Other authors simply associate growth centers with size. Thompson (*92*) points out that, during the fifties, all SMSAs with more than 500,000 persons gained in population. Only two SMSAs between 250,000 and 500,000 persons lost population. After considering why this might have happened, Thompson concluded that irreversible growth may be attained once a threshold size is passed. It was two decades later that Census data demonstrated the dubiousness of his conclusion. During the sixties, two-thirds of the fastest growing quintile of functional economic areas were urban-oriented (that is, their central places were SMSAs). And only one-fifth of the slowest growing quintile (including areas with population losses) were urban-oriented. This experience was consistent with the ideas held by Hansen and Thompson about growth centers. However, during the seventies, the scene changed; half the members of the fastest growing quintile were rural, and half the slowest growing were also rural. There were several functional economic areas with central places of more than 1 million persons in the slowest growing quintile during the seventies, a result contrary to Thompson's view; none of the areas with such large cities had fared so poorly during the sixties.

Multiplier theory is often used to explain the relationship of growth centers to economic development. "The underlying idea of growth center theory," according to Richardson, "is that the spatial concentration of economic activity in an urban center of an underdeveloped region will raise the economic performance of the region as a whole" (*74*, p. 28).

Programs of the U.S. Economic Development Administration (EDA) concentrated on locating firms in the central places of areas with low income or high unemployment on the theory that "accelerating the creation of employment opportunities in or near such centers was believed the most effective and timely approach to providing jobs for residents of neighboring depressed areas" (*98*, p. 10). Berry elaborates the EDA view: "The task of regional policy is seen as one of strengthening key urban centers that can bring growth to the peripheries and the pockets of isolation beyond" (*5*, p. 9). Research is needed, he continues, to identify "potential growth centers capable of exerting uplifting spread effects on their hinterlands." The EDA approach to growth centers became popularly known as the "trickle-down" theory.

After 7 years of operating EDA programs, the U.S. Department of Commerce concluded that the programs were "successful in locating jobs, generating income, and simulating the development process in economically depressed areas" (*98*, p. 78). Cameron (*15*, chap. 3) lists several theoretical reasons why growth center policies for regional development have merit; he adds several practical reasons why growth center policies might fail.

Statistical evidence has been compiled that the multipliers assumed in the trickle-down theory might not always work. Milkman (*62*, chap. 8) analyzed several EDA growth center projects that had been justified on the basis that accelerated economic activity in the center would benefit the entire redevelopment area. In the growth centers evaluated, there was almost no impact on the redevelopment areas or their residents (*62*, p. 209). Lewis and Prescott (*54*) found that 86 labor market areas were relatively stable regions that might respond better to uniform and direct development policies than to indirect multipliers through growth centers. In a study of 85 smaller SMSAs and their hinterlands, Stewart and Benson discovered that population growth in the hinterland was positively correlated with growth in the center during the sixties, but that per capita income was negatively correlated. Their general conclusion was that linkages between the smaller SMSA and its hinterland are very weak (*85*, p. 439).

Hoover concluded that "the multiplier effect through local purchases does not seem to furnish any real rationale for the strategy of concentrating stimuli in growth centers. Indeed, it would seem just as reasonable to invoke this effect in advocating that growth ought to be initiated in the hinterland—to create income and employment in the central place" (*37*, pp. iv, 32, 33).

The evolution of rural development programs in USDA was traced by Sundquist and Davis (*89*). They explained how USDA's rural development activity began as a program for low-income farmers and was expanded to include the rural, nonfarm sector of the economy.

USDA reversed the multiplier logic of EDA and encouraged plant location in rural areas outside the central place:

> The basic theory underlying these . . . efforts is that rural industry can bring about sufficient economic growth to resolve problems of unemployment, underemployment, and low income. . . . the growth center concept should not be overemphasized. . . . modern communication and transportation . . . make decentralized development entirely practical (*109*, p. 6).

Berry (*5*) characterized this approach as "the hot-house industrialization of rural areas." In contrast to the EDA growth center approach, USDA seems to imply that beneficial effects "trickle up" from the hinterland to the center. In general, no such beneficial effects have been substantiated. Many plants placed in locations remote from access to central city services have succeeded, but many others have failed. The success or failure of plants located under these programs was probably due to factors other than either the "trickle down" or "trickle up" process.

Even if shortrun gains from government programs are greater in the growth center than elsewhere, according to Johnson (*44*, p. 217), we should be cautious about concentrating developing programs in such centers because "short-run wisdom may be long-run folly" as spatial income disparities may widen further.

An explanation of how to conquer space will likely never be arrived at by reducing spatial theory to simple multiplier relationships. The problems of communication and transportation over space and their consequences for economic development are more complicated than that.

Urban and Rural Development

Urban economic activity is considered as the basis for progress by some regional development authors, whereas others emphasize the rural areas, and the agricultural subsector in particular, as the basis. As the terms "rural" and "urban" have geographic connotations, these authors imply spatial variations in the sources of progress. Georgescu-Roegen says, "the interests of the town conflict with those of the countryside" (*28*, p. 8).

The literature on central place and on agglomerative relationships, according to Spiegelman (*83*, p. 1), is written mostly from the urban, not the rural, point of view. For example, Friedmann and Miller, in developing their concept of an urban field that extends far beyond existing metropolitan cores, support the idea of expansion of urban life into the rural regions that "intervene among metropolitan regions" (*24*, p. 313). This intermetropolitan periphery is likened to "a devil's mirror, much of [which] has developed a socio-economic profile that perversely reflects the very opposite of metropolitan virility" (*24*, p. 313).

Metropolitan markets trade with each other and, when threshold conditions are reached, they develop a self-regenerative growth pattern according to Berry (*6*). He asserts that growth in the periphery, or hinterlands, depends on capturing a share of downward-filtering industries which develop slowly and yield lower returns. This leads Berry to a view of rural-urban differences in which "the basic regional distinction is, therefore, that between self-regenerative metropolitan America, and the hand-me-down intermetropolitan periphery, condemned to progress characterized at best by lagged emulation and second-hand growth" (*6*, p. 10).

In reviewing the report of the President's National Advisory Commission on Rural Poverty (*67*), *The People Left Behind*, Hansen (*33*, p. 238) finds that it was concerned with the places, not the people, left behind. He sees no need for Government programs to attract industry to the countryside, either from an efficiency or an equity standpoint. However, he finds that Federal investment for education, health, and migration of rural people benefits both rural and urban areas. Hansen would concentrate Federal expenditures for economic development in cities of at least 250,000 persons. He finds that such programs are best based on what he calls intermediate-sized cities, ranging in size from 250,000 to 750,000 persons, because it is easier to accelerate their growth than to accelerate growth in a lagging region. Berry (*5*) explains the rationale: it is not generally feasible to base a national strategy on the industrialization of rural areas; our largest metropolitan areas are already too big, and emphasis on growth in intermediate-sized places provides an alternative to rural poverty other than the metropolitan ghetto.

The strategy described by Hansen and Berry would focus national policy not only away from that half of the functional economic areas which do not have an SMSA for a central place, but also away from a hundred or so more which have a small SMSA at the center. Richardson summarized the urban point of view when he concluded, "cities then become the engine of regional growth" (*76*, p. 154).

The view that there is a one-way flow from urban to rural areas was challenged by Redfield and Singer (*70*). They traced vital interaction and feedback between the two sectors in their discussion of the cultural role of cities. Johnson warned that, despite the greatness of our cities, we ought not to be blinded to their limitations: "Metropolitan centers are both creative and parasitic, elegant and squalid, majestic and pathetic" (*44*, p. vii). "If these [rural] communities did not exist," according to Yasseen and Fulton, "they would have to be invented. They are absolutely essential for the needs of our expanding and decentralizing industry" (*111*, p. 3).

European policies that treated only the largest cities as growth centers were examined by Sundquist (*88*). He found evidence of "a gradual shift in emphasis from the larger to the smaller centers" (*88*, p. 27). Richardson is speaking of developing countries when he says of rural-oriented growth centers: "The traditional view is to interpret their role as 'parasitic,' draining the rural hinterland of resources. . . . However, from another perspective their location in rural areas could be viewed as a potential advantage, provided that policymakers can capitalize on this important locational advantage" (*75*, p. 135).

The distinction between rural and urban is more than geographic. The literature abounds with distinctions that are physical, economic, political, social, cultural, and religious. Heilbroner (*35*) has such distinctions in mind when he speaks of "intellectual and ideological boundaries" in addition to geographic boundaries. But there are others who feel that these distinctions are becoming blurred. Leven (*52*) notes that abrupt demographic changes of the past decade and the spatial dispersion of large, polycentric metropolitan areas. From this he concludes (echoing Kolb and Brunner (*50*)) that "the distinction between metropolitan and nonmetropolitan—or even between urban and rural—may lose, finally, any real definition" (*52*, p. 110).

An agricultural point of view toward the geographic source of growth is reflected in much of the literature of agricultural economists. Agriculture is viewed as a fundamental or leading industry; as agriculture expands, the rest of the region follows. Mosher (*64*) illustrates a broader rural point of view toward central place theory and spatial relationships as a basis for growth in his framework for a progressive rural structure to serve a modern agriculture.

The importance of urban centers to agricultural growth was noted by Schultz (*78*, chap. 9), who proposed an industrial-urban development hypothesis. He emphasizes the spatial element in the development of the agricultural sector and points out that "the process of economic growth does not necessarily occur in the same way, at the same time, or at the same rate in different locations." Schultz notes that demand for agricultural products is inelastic, which tends to limit agricultural growth as the economy grows. He discusses the importance of resource availabilities and, in particular, of participation in the labor force. He calls attention to resource productivity and emphasizes the importance of education and the quality of labor in that productivity. He notes institutional relationships and emphasizes markets that lead to factor-price equalization. Schultz's hypothesis is that all these factors tend to work better near the urban center of a location matrix and work less well around the periphery (*13, 14, 90*). Vining (*104*) detects what he terms a "lack of clarity" owing to "the ambiguity of certain concepts" in Schultz's analysis and seeks to clarify it.

Most of the rural economy in the United States is a nonfarm economy. Rural development is not equivalent to agricultural growth. In fact, technical progress in agriculture can release redundant agricultural labor into the nearby nonfarm rural economy and can thereby have a depressing, rather than a stimulating, effect. A growing commercial agriculture may have closer economic ties with the highly developed urban economy, where it sells products and purchases inputs, than with the spatially contiguous, rural nonfarm economy. An interesting discussion of progress in the nonfarm rural economy by Johnson (*44*, p. 138) recognizes the role of central place in rural development and traces the contributions of Galpin (*26*), Kolb and Brunner (*50*), Kolb (*49*), and Sanderson (*77*).

Conclusion

As the national economy develops, each of its functional economic areas can be expected to change (expand or contract) differently. Regional variations in natural features, such as availability of natural resources and amenities, and the presence of coasts, lakes, rivers, mountains, or plains are enough to guarantee that. Many economic forces are at work differentiating areas even when natural features are equal. Some of these forces are cohesive and lead to the formation of central places and to urban-oriented, functional economic areas. These cohesive forces include transportation costs, risk avoidance, economies of scale, externalities, and agglomerative efficiencies. Other forces are dispersive and lead to the formation of hinterlands to central places and to rural-oriented, functional economic areas. These dispersive forces include access to scattered resources or markets, access to amenities, avoidance of high rent, diminishing returns, and personal preferences.

National policy is needed not only with respect to the distribution of people over geographic space, but also to the distribution of economic opportunity, including access to central city services. Most national distribution policies reviewed here are urban-oriented, and they depend on multiplier effects to reach the hinterlands. Such policies may be of negligible benefit to rural residents, either because the residents do not live within the range of influence of a major urban place or because the multiplier fails to function as intended.

Many rural counties are in the hinterlands of functional economic areas that have SMSAs at their centers. A small number of these centers are very large—over 1 million people. Rural residents or urban-oriented areas generally have commuting access to metropolitan centers for markets, shopping, nonfarm employment, and cultural attractions. Economic development for the rural counties depends not only on access but also on the development prospects for the central city. For example, during the seventies nearly a dozen functional economic areas with central cities of more than 1 million persons suffered a setback from the 1960 growth trends and were included in the slowest growing quintile of all functional economic areas. The rural counties in such areas absorbed some of the nearby urban loss; they grew faster because of the urban setback.

An alternative perspective on rurality has been reviewed here. In this view, many functional economic areas have central places which are smaller than an SMSA. Rural residents in the hinterlands of such areas have commuter access to a different kind of economic activity than do rural residents of urban-oriented areas. Urban-oriented development policy that depends on multipliers to reach rural people can be of little help to residents of rural-oriented areas. Yet the prospects for economic development in such areas are far from hopeless. About a fourth of these rural-oriented areas were in the slowest growing quintile of functional economic areas during the seventies but another fourth were in the fastest growing quintile—evidence that isolated rural areas have the capacity for economic development. Those who direct policies toward residents of rural-oriented areas need to recognize that these residents have access to central places which are not only smaller but also different in character than are the centers of urban-oriented areas. The socioeconomic and physical characteristics of these smaller central places influence the prospects for economic development on nearly half of the U.S. land area, which contains more than an eighth of its people.

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In Earlier Issues

The first condition for the development of any branch of research is that it shall attract scholars of imagination and technical ability.

Frederick V. Waugh (quoting Richard Stone)
Vol. 7, No. 1, Jan. 1955, p. 23

In Earlier Issues

If there were some magic formula that explained the demands for all commodities, at all places and at all times, research in this field would be purely routine. All data could be fed into the electronic computer, together with standard instructions, and we would get the answers without need for thinking. Then we would not need to attract scholars of imagination and technical ability.

Frederick V. Waugh
Vol. 7, No. 1, Jan. 1955, p. 24

Research Review

Global Modeling After Its First Decade

By Donella H. Meadows*

Global models are computer models that address social problems of global scope. To date, seven global models have been constructed by different groups of people in different countries who ask different questions and use different methods.

Among the social problems addressed by these models are the following: resource depletion, poverty and hunger, inequities in international trade, environmental degradation, and rapid population growth.

Among the methods used are the following: simultaneous econometric equations, simulation, optimization, input-output, and systems dynamics.

Not surprisingly, global modelers at the Sixth Global Modeling Conference of the International Institute of Applied Systems Analysis found themselves in fundamental disagreement over several points. Here are some of the most important ones:

1. Should models be built to answer a single, well-defined problem or to represent many aspects of a system and serve diverse purposes?
2. Should models be made in direct response to pressing issues of public policy or should the goal be general improvement in understanding?
3. Should models be normative or descriptive?
4. How far into the future can one see with a model?
5. What is the best method to use for global modeling?
6. Should models be large or small?
7. Should the procedure for developing the model be top down or bottom up?
8. What should be done when data about a crucial system relation are not available?
9. How should actors, technology, prices, population, and other factors be represented?
10. How should a model be tested?
11. What is the appropriate audience for global modeling? When and how should results be communicated to this audience?

Despite these differences, one can draw from the seven global models some common, general messages both about the modeling process and about the state of the world and its future. The fact that global modelers with such disparate backgrounds can agree on anything is noteworthy. The areas of methodological agreement are the following:

1. It is better to state your biases, insofar as you are able, than to pretend you don't have any.
2. Computer models of social systems should not be expected to produce precise predictions.
3. Inexact, qualitative understanding can be derived from computer models and can be useful.
4. Methods should be selected to fit problems (or systems); problems should not be distorted to fit methods.
5. The most important forces shaping the future are social and political, and these forces are thus far the least well represented in the models.
6. In long-term global models, environmental and resource considerations have been too much ignored.
7. Models should be tested much more thoroughly—for agreement with the real world, for sensitivity to uncertainties, and over the full range of possible policies.
8. A substantial fraction of modeling resources should go to documentation.
9. Part of the model documentation should be so technically complete that any other modeling group can run and explore the model and duplicate all the published results.
10. Part of the documentation should be so clear and free from jargon that a nontechnical audience can understand all the model's assumptions and how these assumptions lead to the model's conclusions.
11. Modelers should identify their data sources clearly and share their data as much as possible.
12. Model users, if there are any clearly identifiable ones, should be involved in the modeling process as directly and frequently as possible.
13. An international clearinghouse for presenting, storing, comparing, criticizing, and publishing global models is necessary.

The most important points of agreement on the state of the world and its possible future are the following:

1. There is no known physical or technical reason why basic needs cannot be supplied for all the world's people in the foreseeable future. These needs are not being met now because of social

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and political structures, values, norms, and world views, not because of absolute physical scarcities.

2. Population and physical (material) capital cannot grow forever on a finite planet.
3. There is no reliable and complete information about the degree to which the earth's physical environment can absorb and meet the needs of further growth in population and capital. There is a great deal of partial information, which optimists read optimistically and pessimists read pessimistically.
4. Continuing "business-as-usual" policies through the next few decades will not lead to a desirable future—or even to meeting basic human needs; it will result in an increasing gap between the rich and the poor, problems with resource availability and environmental destruction, and worsening economic conditions for most people.
5. Because of these difficulties, the continuation of current trends is not a likely future course. Over the next three decades, the world's socioeconomic system will be in a period of transition to some state that will be, not only quantitatively, but also qualitatively, different from the present.
6. The exact nature of this future state, and whether it will be better or worse than the present, is not predetermined, but is a function of decisions and changes being made now.
7. Because of the momentum in the world's physical and social processes, policy changes made soon are likely to have more impact with less effort than the same set of changes made later. By the time a problem is obvious to everyone, it is often too late to solve it.
8. Although technical changes are expected and needed, no set of purely technical changes tested in any of the models was sufficient in itself to bring about a desirable future. Restructuring social, economic, and political systems was much more effective.
9. The interdependencies among peoples and nations over time and space are greater than commonly imagined. Actions taken at one time and in one area of the globe have far-reaching consequences that are impossible to predict intuitively and probably also impossible to predict (totally, precisely, or maybe at all) with computer models.
10. Because of these interdependencies, single, simple measures intended to reach narrowly defined goals are likely to be counterproductive. Decisions should be made within the broadest possible context—across space, time, and areas of knowledge.
11. Cooperative approaches to achieving individual or national goals often turn out to be more beneficial in the long run to all parties than do competitive approaches.
12. Many plans, programs, and agreements, particularly complex international ones, are based on assumptions about the world that are either mutually inconsistent or inconsistent with physical reality. Much time and effort is spent designing and debating policies that are, in fact, impossible.

Surely, one reason for the extensive areas of agreement on procedures and findings is the robustness of the conclusions. We tend to arrive at the same answer no matter what direction we take. But there is another possible and worrisome reason: Numerous assumptions underlying all the models are seldom questioned and are held as an act of faith. Among the assumptions that regularly appear in global models are the following:

1. Technology is a crucial factor in global development.
2. The poor nations of the world are developing in the same pattern as the Western industrialized nations, but after a time lag.
3. Political leaders are above the global system, outside it, making the important decisions affecting it, and not affected by it.
4. The most important phenomena in the world are economic and can be described in terms of monetary units.
5. Nation-states are the basic actors in the world, and they interrelate primarily through flows of commodities and money.
6. A good indicator of the welfare of a population is the annual flow of market-exchanged goods and services (measured by monetary value) produced by that population.
7. The questions that interest political leaders are indeed the critical questions that need to be answered.
8. The questions that interest political leaders are narrow and self-serving and not the important ones at all.

Perhaps all these statements are true—or none of them is. But should any of them be accepted unquestioningly as the basis for our global models? Assumptions like these are conceptual walls and interfere with our seeing the world as it really is. Modelers must feel free to put forward creative new hypotheses even if they affront conventional wisdom.

Monthly Food Price Forecasts

By Paul C. Westcott*

Retail food prices in the seventies rose at an 8.0-percent annual rate, or 1.2 percentage points faster than nonfood prices. Double-digit increases in retail food prices occurred in 4 of the past 10 years. These developments have spurred public interest in food prices and in the factors which cause them to change.

My purpose here is to discuss a two-equation linear model that was developed to make monthly food price forecasts. The model provides estimates of price movements of the two major food price components of the CPI—food at home (representing prices in grocery stores) and food away from home (representing prices in restaurants, cafeterias, and fast-food estabishments).

The Model

Much empirical work using price equations has been based on markup models. Popkin suggests a form of the markup model in which prices are examined by their stage of processing "as an approximation to the type of study that could be conducted in an input-output framework" (*7*, p. 486).[1] In this approach the price of any product is represented as a function of prices for inputs used in its production, including prices of raw materials and costs of marketing. The price markup from one stage of processing to the next is also affected by excess demand variables, such as the unemployment rate and capacity utilization.

Heien (*5*) uses this approach in a dynamic monthly model of the food price determination process to examine the farm-to-retail lags for 23 foods. He divides the farm-to-retail marketing process into two stages of processing—farm-to-wholesale and wholesale-to-retail—and estimates markup equations for each stage. Heien's study illustrates that the dynamic nature of the food marketing process is important in food price determination models. In each processing stage, changes in input prices and marketing costs are only partly transmitted to successive stages in the same period, with an additional time period required for all effects to be passed through to retail.

The model used in this article draws on Popkin's idea that product price is a function of input prices, and it draws on Heien's idea that the dynamic nature of the food marketing process is important. The equations use distributed lags and explain retail food prices as functions of prices for domestic foodstuffs, prices for imported foodstuffs, and costs of food marketing.

Estimation Results and Implications

Two major components of retail food prices that interest policymakers and the public are prices for food in grocery stores and prices for food consumed away from home. Because food prepared in restaurants is more highly processed than food purchased in grocery stores, the dynamic properties of the price markup process for the two categories differ. Therefore, two separate price forecasting equations were estimated.

The CPI for food at home and the CPI for food away from home are used as dependent variables. The index of prices received by farmers for foodstuffs (PRF),[2] the Producer Price Index (PPI) for raw sugar, and the food marketing cost index (MCI) are independent variables. PRF approximates the domestic farm value of retail food.[3] Sugar is a major imported food that is domestically consumed. Therefore, the model uses the PPI for raw sugar to represent prices for imported foodstuffs.[4] MCI represents the major inputs used in processing, distributing, and retailing food.[5] Monthly data from 1971 through 1979 with all variables expressed as percentage changes from the previous month were used to estimate each equation. The 12 months of 1980 were saved for beyond-sample validation.

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*The author is an economist with the National Economics Division, ERS. The helpful comments of R. McFall Lamm, Jr., Harry Harp, Denis Dunham, and Leland Southard are gratefully acknowledged. Opinions presented here do not necessarily reflect those of the U.S. Department of Agriculture (USDA).

[1] Italicized numbers in parentheses refer to items in the references at the end of this article.

[2] The PRF index is an aggregate of 37 farm-level commodity prices. It is similar to the index of prices received by farmers for all farm commodities, but nonfood items have been removed. For example, cotton and tobacco prices (which are included in the price index for all farm products) are not included in the PRF. The remaining foodstuffs components are aggregated by use of new relative weights derived from appropriate adjustment of the original set of weights. This index and the weights used in its construction are discussed in (*10*).

[3] The PRF index is used rather than USDA's farm value of the market basket data because it is published earlier. Therefore, retail food price forecasts can be provided to policymakers and the public almost 1 month in advance of the release of the CPI.

[4] Coffee prices were initially included, but they did not add significantly to the model in the estimation stage.

[5] The food marketing cost index is a price measure representing 40 major inputs used in processing, distributing, and retailing food. For a further discussion, see (*3*).

In the food-at-home equation, two binary variables, C_1 and C_2, were included for August and September 1973—months at the end of the Nixon administration's price freeze. Large price changes for food at home occurred in these months (a 7.4-percent increase in August and a 1.4-percent decrease in September), caused largely by policy considerations outside normal food marketing operations.[6] C_1 is equal to 1 for August 1973, and to zero otherwise. C_2 is equal to 1 for September 1973, and to zero otherwise. Monthly dummy variables (D_i) were also included to represent seasonal effects. D_i equals 1 in the *i*th month of each year, and zero elsewhere. The equation was fit by ordinary least squares.

For the away-from-home equation, polynomial distributed lags were estimated from the generalized Almon procedure which uses the Lagrangian interpolation formula to estimate the polynomial function. The lag lengths used were 6 months on PRF and 4 months on MCI. Because significant autocorrelation was present in the initial estimate (the Durbin-Watson statistic is 0.91), the Cochrane-Orcutt autocorrelation adjustment procedure was used.

The estimated equations for food at home (1) and food away from home (2) are as follows:

$$\begin{aligned}
&\underset{(.127)}{-.188} + \underset{(.023)}{.048\,F_t} + \underset{(.023)}{.147\,F_{t-1}} + \underset{(.016)}{.061\,F_{t-2}}\\
&+ \underset{(.129)}{.510\,M_t} + \underset{(.005)}{.012\,S_t} + \underset{(.765)}{5.897\,C_1} - \underset{(.825)}{4.448\,C_2}\\
&+ \underset{(.234)}{.385\,D_1} + \underset{(.219)}{.666\,D_2} + \underset{(.211)}{.865\,D_6} + \underset{(.209)}{.427\,D_7} + \underset{(.215)}{.750\,D_{12}}\\
&R^2 = .756 \quad d = 1.77 \quad \Sigma f_i = .256 \quad \bar{f} = 1.048 \qquad (1)
\end{aligned}$$

$$\begin{aligned}
&\underset{(.108)}{.043} + \underset{(.005)}{.001\,F_t} + \underset{(.004)}{.019\,F_{t-1}} + \underset{(.005)}{.028\,F_{t-2}}\\
&+ \underset{(.005)}{.029\,F_{t-3}} + \underset{(.005)}{.025\,F_{t-4}} + \underset{(.004)}{.018\,F_{t-5}}\\
&+ \underset{(.003)}{.008\,F_{t-6}} + \underset{(.038)}{.191\,M_t} + \underset{(.040)}{.163\,M_{t-1}}\\
&+ \underset{(.035)}{.146\,M_{t-2}} + \underset{(.036)}{.125\,M_{t-3}} + \underset{(.036)}{.082\,M_{t-4}}\\
&R^2 = .710 \quad \varrho = .566 \quad \Sigma f_i = .129 \quad \bar{f} = 3.131\\
&\Sigma m_i = .707 \quad \bar{m} = 1.639 \qquad (2)
\end{aligned}$$

where:

F = PRF, or prices received by farmers for domestic foodstuffs;
M = MCI, or food marketing cost index;
S = Producer Price Index for raw sugar;
C = Dummy variables, end of price freeze, 1973; and
D = Seasonal dummy variables.

The standard errors are shown in parentheses; *d* is the Durbin-Watson statistic; ϱ is the autocorrelation adjustment parameter; Σf_i is the sum of the farm value lag coefficients; $\bar{f}$ is the mean farm value lag (in months); Σm_i is the sum of the marketing cost lag coefficients; $\bar{m}$ is the mean marketing cost lag (in months). The subscripts of F, M, and S denote time periods.

Using Theil's explanatory set reduction strategy (*9*), I omitted insignificant variables from the final specification. Most of the sugar price variables were not statistically significant and were dropped from the equations. Only the current sugar price in the food-at-home equation was included. All lagged marketing cost variables were dropped from the food-at-home equation, as were six of the monthly dummy variables. All dummy variables were omitted from the food-away-from-home equation.

Most of the estimated structural parameters are of the expected sign (positive), and most of the estimates are statistically significant. The negative constant term in the food-at-home equation is not statistically different from zero.

The signs on the binary variables in the food-at-home equation are as expected. The price-freeze dummy variables reflect events in the livestock sector at that time (see fn. 6). The positive sign on the December dummy variable reflects increased holiday demand. Similarly, the estimated coefficients on the June and July dummy variables probably reflect increased demand for food at home for summer barbeques and picnics.[7] The signs on the January and February dummy variables probably reflect seasonal supply disruptions due to weather.

The difference between the two equations regarding price transmission lags for PRF is interesting. For food at home, the largest impact is in the first lag period, with smaller impacts in the preceding and following months (see figure). The mean lag is 1.048 months, indicating that price changes for foodstuffs are passed through to retail prices quickly, averaging about 1 month.

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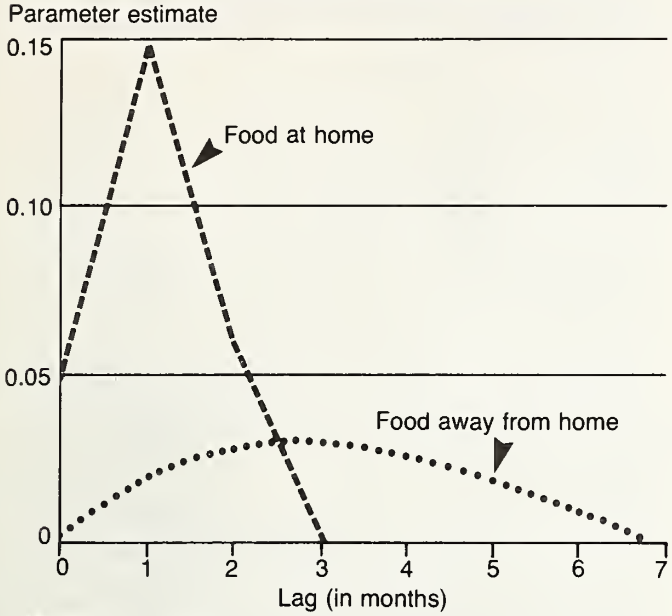
[6] Price ceilings on pork ended in July 1973, resulting in sharp hog and pork price increases in August. "The announcement in July that beef price ceilings would be lifted in September and the observed jump in hog prices when ceilings were lifted on pork encouraged cattle feeders to hold back cattle nearing market weights for expected higher prices in September" (*11*, p. 5). This not only pushed up meat prices in August, but also caused large cattle marketings and a price decline in September.

[7] Dummy variables for November and August were not statistically significant. Because the CPI survey throughout most of the estimation period was conducted during the first week of each month, retail food prices in the November CPI probably did not reflect increased holiday demand. The shift of some demand to the away-from-home market in August—when many people take vacations—probably offset higher summer demand for food at home.

Estimated Coefficients for Current and Lagged Domestic Foodstuffs Price Variables



For food away from home, the impacts increase each month through the third lagged period, before diminishing through the sixth lagged month. The mean lag is 3.131 months, indicating a slower retail price response to price changes for foodstuffs than in the at-home market. The coefficient on current PRF in the food-away-from-home equation is not statistically different from zero, implying a lag before any effects of domestic foodstuff price changes are reflected in food-away-from-home prices. These results are likely caused by delays in menu pricing adjustments and by future contracting for food supplies in that market.

Changes in food marketing costs also affect retail prices faster in the at-home market. In the food-at-home equation, only current marketing costs are statistically significant, indicating that the pass through to retail generally occurs in the same month. In the food-away-from-home equation, the largest impact is in the current period with smaller effects occurring through the fourth lagged month. The mean lag of 1.639 months again indicates a slower retail price response to changes in marketing costs.

The role of farm value changes and of marketing cost changes is another important result. The sum of the lag coefficients of PRF in the at-home equation, an estimate of the longrun effect of a 1.0-percent change in prices for foodstuffs, is 0.256; whereas in the away-from-home equation the sum is 0.129. This implies that foodstuff price changes are more important to the at-home market than to the away-from-home market. Conversely, marketing cost changes play a larger role in the away-from-home market, reflecting the larger amount of processing required. The marketing cost coefficient in the at-home equation is 0.510, whereas the sum of lagged marketing cost coefficients in the away-from-home equation is 0.707.

Validation

To validate the model, I performed a deterministic simulation of the model to generate estimated time series for the endogenous variables. I compared these to the actual endogenous values and calculated summary validation statistics. For both equations, I made within-sample (1971-79) and beyond-sample (1980) comparisons. Because the exogenous data are available prior to the release of the CPI and because this model is primarily intended for forecasts 1 month ahead, I used actual exogenous data in all simulations.

The table shows summary validation statistics for both the within-sample and beyond-sample simulations. The food-away-from-home equation performs very well as a forecasting tool. The Theil inequality coefficients are well below unity and the mean absolute errors are relatively small. However, a less satisfactory performance is indicated for the food-at-home equation. Although the Theil inequality coefficients are well below unity, the mean absolute errors are relatively large.

Summary validation statistics

Consumer Price Index category	Within sample		Beyond sample	
	Mean absolute error	Theil inequality coefficient	Mean absolute error	Theil inequality coefficient
Food at home	0.40	0.42	0.40	0.54
Food away from home	.14	.24	.14	.22

These results are a consequence of the larger variation in food-at-home prices, reflecting the structures of each market regarding both its lag pattern and the relative importance of prices for foodstuffs and marketing costs. Prices for foodstuffs are more volatile than are food marketing costs, largely because of the seasonal nature of agricultural production and the weather's important role in determining supplies. As prices for foodstuffs are more important in determining at-home prices, prices in grocery stores reflect this variation more than away-from-home prices. Furthermore, the longer lag structure in the away-from-home market distributes changes in prices of foodstuffs over more months, thereby reducing the volatility of impacts at the retail level.

Conclusions

I have estimated a distributed lag model with equations for the CPI for food at home and for food away from home to forecast the two major aggregate components of the food CPI. Validation statistics from simulations for the within-sample period and for a 12-month beyond-sample period indicate that reasonably good forecasts 1 month ahead can be made for the food-away-from-home CPI, with less satisfactory forecasts obtained for the more volatile food-at-home CPI.

The model estimates are consistent with U.S. Department of Agriculture marketing bill data, which indicate agricultural commodity price changes are a larger part of the price determination process in the at-home market than in the away-from-home market. The estimated coefficients of prices for foodstuffs and prices for marketing costs also indicate that the price transmission lags characterizing the pricing of foods in grocery stores are shorter than those depicting price changes for food away from home.

The Economic Research Service (ERS) makes monthly forecasts of retail food prices. The two equations discussed here draw on exogenous data on prices for domestic and imported foodstuffs and on marketing costs that are available at the time the price forecasts are needed. These equations have proven useful in meeting the demands on ERS for shortrun food price forecasts.

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In Earlier Issues

Many people who observe day-to-day prices in commodity markets believe that prices follow certain patterns of movement, or that their fluctuations can be traced to various causal factors. An attempt to discover such patterns was unsuccessful. Because the problem is important, the negative findings are set forth.

Richard J. Foote
Vol. 7, No. 1, Jan. 1955, p. 19

Costs of Marketing Slaughter Cattle: Computerized versus Conventional Auction Systems

By Steven T. Buccola and Alice M. Chieruzzi*

Geographical dispersion of beef and dairy farms in the United States impedes not only the rapid dissemination of cattle price information, and hence cattle pricing efficiency, but also the technological efficiency of cattle transactions. Electronically operated markets, employing conference-call telephone, teletype, or computer, can increase the technological efficiency of cattle markets by eliminating the need for the physical proximity of buyer and seller. Although under such arrangements cattle buyers cannot visually inspect animals before purchase, it has become increasingly clear that they can rely on written descriptions of cattle to adequately determine their value. Remote purchases eliminate the buyers' expense of sending representatives to each purchase point. Thus, buyer procurement costs may be reduced, thereby increasing the number of buyers willing to bid on cattle at each locality.

The extent to which an electronic exchange reduces marketing costs is an empirical question. In this article, we summarize a study in which the simulated costs of operating a computerized livestock auction market in Virginia were compared with the costs of the current, conventional auction arrangement (*1*).[1] The analysis was part of a project to set up a computer-based livestock auction system.

Computerized Sales Procedures

Computerized sales of slaughter cows and lambs began in Virginia in mid-1980 (*7*). Although the volume of these sales is a small fraction of total State and regional marketings, participation is expected to increase as the industry becomes familiar with the new concept. Auctions are conducted by a nonprofit organization, the Eastern Electronic Marketing Association (EEMA), through time-shared access to commercial computer facilities. Livestock are assembled, weighed, and graded at participating auction markets; then descriptions of consignments are phoned to EEMA headquarters or entered on a portable terminal at the market. Prior to a sale, buyers log on at terminals in their packing plants and receive printed descriptions of available livestock.

Unlike electronic hog sales in Canada, which employ Dutch auctions, EEMA auctions follow English (ascending) bids. Bidding for a particular lot is initiated when an EEMA representative enters an asking price at a central terminal. At preset intervals, buyers receive a display of the current high bid and the number of seconds left in which to raise that bid. Only the high bidder knows who has the high bid. The bid is raised a preset increment when a prospective buyer pushes a key on the terminal. A transaction is terminated when no buyer has raised the current high bid in the alloted time. Summary information is then printed at buyer terminals indicating the description, price, and market location of the animals. Buyers are responsible for arranging the transportation of these animals to their plant.

We develop here the general structure of costs associated with time-shared computerized auction sales; we then compare these costs, given alternative assumptions, with those of conventional sales. Our characterization of handling and transportation costs specifically applies to slaughter cattle and to Virginia, although the general methods and conclusions would probably also apply to other commodities and to other States.

Cost Structures

Variable costs of computerized auction sales are those that vary with the number of lots offered per week. The major variable costs of a time-shared computerized sale are those associated with entering and obtaining descriptions of lots and with conducting an auction. Each requires computer connect time, line printing, the user's own time, and computer processor usage.[2] Fixed costs include terminal depreciation and EEMA office and management costs. The table lists 17 components of cost used in the analysis, together with their 1980 values.

Entering Lot Descriptions at Market and EEMA Terminals

It takes approximately 1.2 minutes for each auction market or EEMA terminal operator to log on and off the system each day, so that a total of 1.2 $S_w MK$ minutes are required for this purpose each week. It also takes an average of 2.3 minutes to enter information on each lot offered for sale. Thus, the total weekly costs of computer connect time (CC_{eL}) associated with lot entry are:

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*Buccola is an assistant professor, Department of Agricultural and Resource Economics, Oregon State University, and Chieruzzi was formerly a research assistant, Department of Agricultural Economics, Virginia Polytechnic Institute and State University. The study was conducted when the authors were resident at Virginia Tech. It was part of the project, "Establishing a Centralized Electronic Marketing System for Cattle," financed by the Agricultural Marketing Service, U.S. Department of Agriculture. Thanks are due to Wayne Purcell and Jim Bell, who were the principal investigators of the project at Virginia Tech, and to Jim Russell.

[1] Italicized numbers in parentheses refer to items in the references at the end of this article.

[2] Some computer time-sharing enterprises charge separately for the number of lines printed. We included these charges in the connect time charge.

$$CC_{eL} = (1.2S_w MK + 2.3A_w/A_L)C_m \quad (1)$$

and the corresponding cost of entry operator labor is $CC_{eL}SW_m/C_m$. Furthermore, it requires approximately 4.0 units of processor resource usage (SRU's), representing core use, I/O operations, and processor time, to enter each lot at each terminal.[3] Total weekly cost (PC_{eL}) of processor usage for lot entry is thus:

$$PC_{eL} = (4A_w/A_L)C_{sru} \quad (2)$$

Obtaining Lot Descriptions at Buyers' Terminals

It is assumed that buyers first request a short description of all lots offered that includes information on the size, average weight, average quality grade, and location of each lot. They then request longer descriptions, including weight and grade ranges and weighing conditions, of the L_{Ld} number of lots that interest them. It takes an average of 2.08 minutes to log on and off and to wait for descriptions. Each short description requires an average of 0.06 minute, and each long description, 0.60 minute. Hence, weekly costs of computer connect time (CC_d) to obtain descriptions are:

$$CC_d = [(2.08 + 0.60\,L_{Ld})BT_sS_w + 0.06BT_s(A_w/A_L)]C_m \quad (3)$$

and the associated cost of terminal operator time is CC_dBW_m/C_m.

It takes an estimated 3.0 SRU's for each buyer to log on and off the system, 0.65 SRU for each long lot description, and 0.03 SRU for each short lot description. Thus, the weekly processor cost (PC_d) for obtaining lot descriptions at all buyer terminals is:

$$PC_d = [(3 + 0.65L_{Ld})BT_sS_w + 0.03BT_s(A_w/A_L)]C_{sru} \quad (4)$$

Conducting a Sale

Buyers are expected to log off the system after obtaining lot descriptions, then log on the system 5 minutes before a sale. Because there are $M_{tL}BT_s(A_w/A_L)$ total buyer connect minutes per week during sales, the total weekly computer connect cost (CC_b) to conduct sales is:

$$CC_b = [5BT_sS_w + M_{tL}BT_s(A_w/A_L)]C_m \quad (5)$$

and the weekly cost of buyers' time is CC_bBW_m/C_m.

About 3.8 SRU's of processor usage are involved in a buyer's logging on and off; 0.091 SRU is consumed each time a buyer pushes the bid key; and 0.063 SRU is used each time the current high bid price is displayed at buyers' terminals. Thus, the weekly cost (PC_b) of processor usage during the course of a sale is:

$$PC_b = [3.8BT_sS_w + (0.063M_{tL}/SEC_{dp} + 0.091BD_{bt})BT_s(A_w/A_L)]C_{sru} \quad (6)$$

a function of the number of sales held each week, the total connect time of all buyers, and the total number of bids made.[4]

Conventional Auction Sale Costs

The cost of conducting a conventional auction sale consists of (1) the auctioneer's fee, (2) ringmen and bookkeeper labor and facility expenses, and (3) the cost of buyers' time. The first two represent a small cost when spread over normal market volumes (*5*), but the cost of buyers' time is considerable. Beef packers normally obtain a portion of their auction market cattle through agents (order buyers) who charge a flat rate, currently near \$2.50 per head purchased. The remainder of the cattle are bought by packers' employees (packer buyers). The fixed weekly cost of supporting a fulltime packer buyer in the East, including travel expenses, is between \$620 and \$700.

Transportation and Handling Costs

The costs of transporting and handling cattle for computerized and conventional auction sales would not necessarily differ. Regardless of sales arrangements, cattle must be shipped from farm to market; weighed, graded, and penned; and then transported from market to plant.[5] For farmers located far from a market that participates in computerized sales, farm-to-market transport costs would generally be higher for computerized than for conventional sales. Total per head costs of farm-to-market hauling were specified as $[(FC_{yr}/365) + VC_{mi}RMI]/A_{trp}$. An average market-to-plant rate of $0.041 per head-mile was assumed, and variable and fixed costs of weighing, grading, sorting, and penning were derived from (*5*).[6]

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[3] The processor resource usage estimates in this article are specific to the FORTRAN software package (which was developed by Computer Sciences Corporation) currently employed by EEMA and to the computer used (a Univac 1108).

[4] Besides these variable costs, weekly terminal ownership costs are \$4.40, weekly software storage costs are \$15.53, and weekly EEMA manager and office expenses are approximately \$437.50.

[5] Transportation cost data were drawn from a random survey of Virginia cattle producers and dairymen (*6*) and from studies by Nor and Kuehn (*4*) and by Lin and Kuehn (*3*). In 1980 dollars, variable costs of handling were \$1.26 per head and fixed costs of handling were \$948.32 per week (weighted average of all market sizes).

Cost Results

Models of marketing costs provide a rational basis for firms' shortrun operating policies. They also serve as a guideline for expansion/contraction plans of firms or firm groups and, in the present case, suggest conditions under which computerized auctions might be more efficient than conventional sales.

Computerized Auction Operations

As an example of an application to shortrun operating policies, this model can be used to predict the impact of marginal changes in operating procedures or volumes on total computerized selling costs. Such predictions can be used as a basis for an efficient EEMA pricing policy. Costs of computerized auctions are responsive to the average number of minutes required to sell a lot (M_{tL}), the average number of head sold per lot (A_L), and the total number of head sold per week (A_w).

Summing equations (1) through (6) yields an equation for total weekly cost (Σ). Successively differentiating this sum with respect to each of the three factors and evaluating the derivatives at parameter values listed in the table will yield:

$$\partial\Sigma/\partial M_{tL} = 4.97/A_L \tag{7}$$

$$\partial\Sigma/\partial A_L = -16.2255/A_L^2 \tag{8}$$

$$\partial\Sigma/\partial A_w = -759.81/A_w^2 \tag{9}$$

Equation (7) shows that weekly operating costs per head decrease with the time required to sell a lot, but that the rate of decrease diminishes with increases in the average lot size. For example, if an average of 20 head are sold per lot, decreasing the average time to sell a lot from 3 to 2 minutes would decrease auction costs by $0.25 per head. The cost decrease would be $0.17 per head if an average of 30 head were sold per lot. In equation (8), the cost economies of increasing lot size are very large at low lot sizes (5-10 head), but decrease rapidly at larger lot sizes. For example, a savings of $0.16 per head is achieved by increasing lot size from 10 to 11 head, but only $0.04 per head is saved by increasing lot size from 20 to 21 head. Economies with respect to weekly sales volume (equation (9)) behave similarly.

Computerized versus Conventional Costs

For purposes of designing longrun government and industry policies on electronic marketing, comparing the total costs associated with computerized and conventional cattle marketing (including selling, handling, transportation, and buyer time) is helpful. We assume that a total of 4,400 head of slaughter cattle can be sold in the State each week, that in the conventional marketing system the average slaughter animal is sold 1.5 times before delivery to

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[6] We obtained these figures from conversations with industry personnel and believe they are approximately correct; however, they were not derived from systematic sampling.

Terms used in analysis of computerized auction costs

Term	Definition	Amount
A_L	Number of head per lot offered for sale	20.0
A_{trp}	Number of head hauled per farm-to-market trip	2.5
A_w	Number of head per week offered for sale	200-4200
BD_{bt}	Average number of bids per connected buyer terminal per lot	2.0
BT_s	Number of buyer terminals connected per sale	20.0
BW_m	Imputed wage of terminal bidder, in dollars per minute	$0.167
C_m	Cost of computer connect time, in dollars per minute per terminal	$0.158
C_{sru}	Cost of computer processor usage, in dollars per SRU	$0.36
FC_{yr}	Weighted average fixed costs of farm truck ownership, in dollars per year	$1,377.93
L_{Ld}	Average number of long lot descriptions requested per buyer per sale	10.0
M_{tL}	Connect time for auction bidding process, in minutes per lot per terminal	3.0
MK	Number of terminals at auction markets and EEMA entering lots for a single auction sale	11.0[1] 26.0[2]
RMI	Average round-trip distance between farm and participating auction market, in miles	62.0[1] 26.0[2]
S_w	Number of computerized auction sales held per week	5.0
SEC_{dp}	Elapsed time between displays of current high bid, in seconds	20.0
SW_m	Imputed wage of lot entry operator, in dollars per minute	$0.083
VC_{mi}	Weighted average variable costs of farm truck use, in dollars per round trip mile	$0.284

[1] 9-market scenario
[2] 41-market scenario

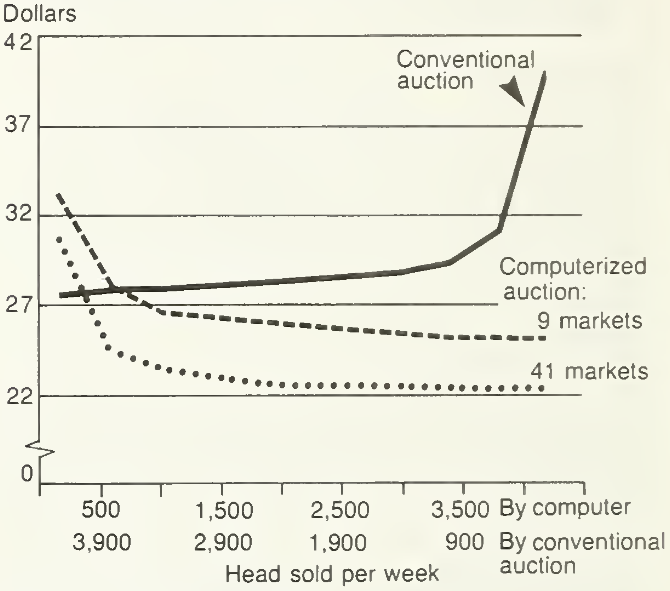
plant, and that 80 percent of packers' slaughter cattle is purchased by order buyers and 20 percent by packer buyers (see fn. 6).

The figure compares the total per head costs of each system as the proportion of cattle sold through computerized sales is increased and as the proportion sold through conventional sales is decreased. The upward-sloping curve indicates that total marketing costs under the conventional auction system are approximately $28.00 per head when 4,200 head per week are sold conventionally (200 head sold by computer), but costs increase to approximately $40.00 per head when only 200 head are sold conventionally (4,200 head sold by computer). The decreasing volume over which fixed packer buyer costs are spread as computerized sales are substituted for conventional sales is largely responsible for this cost increase.[7]

Total per head costs of the computerized marketing system (represented by the downward-sloping lines in the figure) depend on the number of auction markets that participate as information entry points and as handling, weighing, and grading stations. As the number of such markets increases, costs of computer connect time and terminal ownership increase, but the average distances (and hence the per head transportation costs) from farm to market decrease. This relationship is shown by the downward shift in the per head cost function as participation increases from 9 to all 41 markets in the State. The negative and approximately hyperbolic slope of each of these functions results from the spreading of a larger volume of cattle over such fixed auction costs as terminal ownership, time to log on, and time to obtain long descriptions. Most costs of time-shared computerized auctions vary with respect to the number of head sold.

The points at which the upward-sloping line intersects downward-sloping lines indicate volumes at which computerized marketing costs equal conventional marketing costs (see figure). The intersection point varies little with the number of participating markets. Total costs of marketing cattle are lower under the computerized system than under the conventional system if at least 500 head per week—that is, 11 percent of the State's volume—are sold by computer. Although the height of the conventional system's cost line is sensitive to the assumed number of times a conventionally auctioned animal is resold before slaughter—1.5 times in this example—volume points at which computerized costs begin to fall below conventional costs in the 41-market scenario are little affected by the assumed number of resales.

Costs per Head of Marketing Slaughter Cattle, Virginia, 1980*



*See table for parameter assumptions.

Conclusions

When all marketing costs (including handling, transportation, and buyer procurement activities as well as auctioneering) are considered, per head costs of computerized cattle sales in Virginia are less than those of conventional sales if a minimal volume is sold by computer. This conclusion complements arguments made by other researchers that electronic markets encourage competition and access to market information, and thus promote pricing accuracy (*2*).

We do not address the important issue of the optimal, or likely, distribution of the computerized system's cost savings between producers and packers. In the short run, packers will likely retain most of these savings in return for the risks they perceive as early adopters of the new technology. In the longer run, as their perceived risks diminish, buyers will probably begin to pass on their cost savings in the form of higher prices paid to farmers and lower prices charged to food retailers.

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[7] If conventionally auctioned volume fell below 500 head per week, packers would possibly increase the proportion of cattle that they purchase through order buyers and would almost certainly limit their own buyers' activities to a part-time basis. In addition, fewer sales would be held, with a view to utilizing auctioneers' and bookkeepers' time more efficiently. These reactions would reduce the steepness of the cost increase shown at the right end of the conventional auction line. It is difficult to quantify these adjustments as the precise longrun responses to reduced conventional purchases is unknown. The figure represents a shortrun situation in the sense that fixed costs are held constant throughout the entire volume range.

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In Earlier Issues

Among all economic cycles that alternately bring cheer and despair to their participants and continuously challenge the ingenuity of analysts, none presents so rhythmic a pattern as does the cycle in cattle numbers.

Harold F. Breimyer
Vol. 7, No. 1, Jan. 1955, p. 1

Survival Strategies for Agricultural Cooperatives

Charles E. French, John C. Moore, Charles A. Kraenzle, and Kenneth F. Harling.
Ames, Iowa: Iowa State University Press, 1980, 278 pp., $14.25.

Reviewed by Randall Torgerson*

Government, university, and farm leaders interested in the future of agricultural cooperatives are urged to examine *Survival Strategies for Agricultural Cooperatives.* The central question is stated clearly in the last chapter: "Will U.S. agricultural cooperatives survive another decade?" The authors answer affirmatively, but suggest that survival will depend on self-determination—that is, on cooperative members guiding their own destiny. The authors suggest ways cooperatives can survive and expand in a food industry characterized by rapid structural change and in a dynamic economic and political environment.

Research for this book began in 1974. In the preliminary chapters, the authors compare the past and present purposes of cooperatives by evaluating articles and bylaws and by examining the content of oral interviews with key cooperative leaders and academicians. They identify the social and economic roles of cooperatives, their advantages and disadvantages, and issues related to their growth. They also examine the competitive environment in marketing stages (from farm equipment suppliers to food distributors).

The authors suggest that cooperatives might pursue the following three general strategies: (1) further integrating and coordinating, (2) collective bargaining, and (3) maintaining and improving the open market. They develop these strategies on which their book is focused in part from their extensive interviews with cooperative leaders. The authors strongly encourage stepped-up and comprehensive long-range planning by cooperative members to foster these growth objectives.

These three general strategies are not new to readers familiar with cooperative growth and development. However, the authors have added to these strategies, organizational and policy issues. They emphasize planning initiatives to guide future development. Readers will find the discussion on integration and coordination deficient regarding its possible impact on farm structure and regarding the alternative organizational options of producers. However, the section on bargaining strategy is well written and assesses the potential problems of the cooperative community. The authors recognize that improving the open-market strategy may appeal to farmers' conservative orientation, but it is "in opposition to most changes in business structure and organization occurring in recent years."

The authors allude to, but do not adequately treat, the relationship of cooperatives to general farm organizations and other types of group action. Concerning the current issue of farm structure, they are strangely silent, and they fail to recognize the significance of departures from the family farm system and their implication for cooperatives.

The authors conclude that the following points are essential to cooperative growth and well being. Cooperatives must: (1) increase product and financial commitment, (2) improve marketing as well as selling, (3) do more and better long-range planning, (4) make greater use of multicooperative organizations, (5) develop or improve market information systems, and (6) expand product research and development.

The book is comprehensive, relevant, and timely. Those interested in the economic, social, political, and technical environment faced by farm operators and their cooperatives will find the information extremely useful. The authors summarize numerous studies of the competitive market environment and changing structure by the U.S. Department of Agriculture's Agricultural Cooperative Service. This examination of current cooperative efforts in farm inputs and first-handler level marketing activities lays a solid foundation for an inquiry into cooperative alternatives and future directions.

Cooperative board members, managers, policymakers, and scholars should find the reference material on marketing issues useful. As a study oriented not only to survival but also to improvement, the book should be required reading for all farm leaders interested in the future economic wellbeing of agricultural cooperatives.

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*The reviewer is the administrator of the Agricultural Cooperative Service, U.S. Department of Agriculture.

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